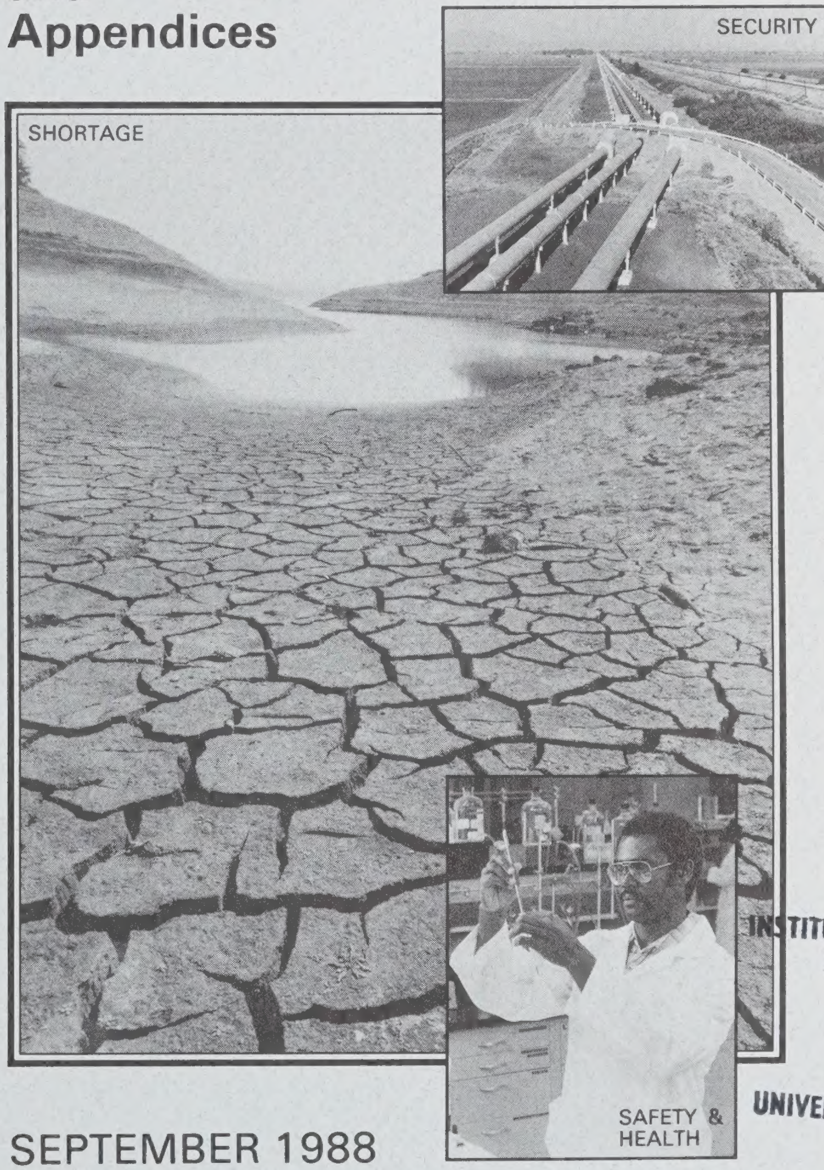
# WATER SUPPLY MANAGEMENT PROGRAM

## Technical Report and Appendices






SEPTEMBER 1988

East Bay Municipal Utility District

EBMUD

Volume II: Revised Draft EIR

# WATER SUPPLY MANAGEMENT PROGRAM

## TECHNICAL REPORT AND APPENDICES

# COMPOSITION OF REVISED DRAFT EIR

This revised Draft EIR on the Water Supply Management Program is comprised of the following:

- Volume I, Revised Draft Environmental Impact Report
- **Volume II, Technical Report and Appendices**
- Volume III, Comments and Responses

# ACKNOWLEDGEMENTS

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Resources Planning Division Staff

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Greg H. Walker, Associate Civil Engineer
Dennis J. Metaxas, Associate Civil Engineer
Arthur K. Lee, Assistant Civil Engineer
John K. Leung, Assistant Civil Engineer
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Jacqueline Millet, Junior Civil Engineer
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Dennis O. Whiteneck, Senior Civil Engineer
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# PREFACE

In February of 1987, EBMUD staff prepared a discussion paper to initiate the public review and input process on the scope and content of the Water Supply Management Program and related Environmental Impact Report. On March 17, 1987, EBMUD staff conducted a public meeting to discuss and solicit comments on the discussion paper. In April 1988, the Water Supply Management Program Draft Environmental Impact Report (DEIR), Technical Report and Summary were circulated for public review. On May 18, 1988, a public meeting was conducted by EBMUD staff and on May 25, 1988, a public hearing was conducted by EBMUD Board of Directors to discuss and solicit comments on the reports. Based on both written comments and comments received during the public hearing and public meeting, a revised DEIR, Technical Report and Summary have been prepared. This Technical Report discusses the water supply issues and problems facing EBMUD customers and alternative solutions to these problems. The economic impacts of the costs of the proposed projects are also included in this report. A revised Draft Environmental Impact Report (DEIR) and a Summary document covering both the Technical Report and DEIR have also been prepared in conjunction with this Technical Report. Modifications made to all the reports are indicated in bold lettering.

WATER SUPPLY MANAGEMENT PROGRAM

TECHNICAL REPORT

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# Introduction

## PURPOSE OF REPORT

East Bay Municipal Utility District (EBMUD) is facing several major water supply problems. The major problems are an increasing risk of failure of the Mokelumne Aqueducts, an increasing frequency of shortage in dry periods, and maintenance of high quality drinking water.

The Water Supply Management Program identifies the actions and projects necessary to solve these problems and discusses the technical and economic feasibility of various alternative actions and projects. The report presents the elements for the District's Water Supply Management Program and provides the basis for preparation of the environmental impact report.

## ACTION BY EBMUD

### Public Briefings by EBMUD Staff

In addition to the public comment period in 1987 and the public hearings and meetings scheduled for this spring, EBMUD staff has made a concerted effort to brief agencies and organizations on the key issues and needs and to respond to different viewpoints about the program.

**The District had made the draft of this report and the accompanying Draft Environmental Impact Report (DEIR) available for public review and had held a public meeting on May 18, 1988 and a public hearing on May 25, 1988. The report and the DEIR have been modified, where appropriate, to incorporate comments received from the public, interested organizations and other agencies. A Final EIR will be submitted for EBMUD Board of Directors' approval in November 1988.**

The EBMUD Board of Directors will formally consider the projects and the EIR for the Water Supply Management Program. The following actions will be recommended to the Board:

1. Accept the technical report.

2. Certify that the Final EIR has been completed in compliance with the California Environmental Quality Act (CEQA) for all near-term projects.

3. Adopt the Water Supply Management Program and authorize the continuation of the projects proposed for the program:

   - Water Supply Objectives
   - Program Elements
   - Specific Projects and Actions

### Future Action

Construction of any facilities approved as part of the program could require an additional sequence of actions, such as the following:

- Additional geotechnical investigation.

- Field testing of conservation techniques and pilot tests.

- Application to the Corps of Engineers for a permit under Section 404 of the Clean Water Act.

- Coordination with cities, counties, and other agencies regarding the impacts of construction and construction traffic.

- Design of the facilities and preparation of plans and specifications.

- Competitive bidding and award of construction contracts.

## WATER SUPPLY OBJECTIVES

EBMUD's water supply problems and needs focus on three basic issues — security, shortage, and safety and health. These issues establish the objectives for development of the Water Supply Management Program:

SECURITY: Provide security of the water supply against delivery system outages caused by floods and earthquakes.

SHORTAGE: Provide an adequate water supply to meet dry year demands.

SAFETY AND HEALTH: Maintain a standard of high water quality.

## DISTRICT BACKGROUND

### Service Area

EBMUD supplies water to approximately 1.1 million people. The service area covers 310 square miles and includes twenty cities and sixteen communities in portions of Alameda and Contra Costa Counties.

The 20 cities served by EBMUD's Water System include Alameda, Albany, Berkeley, Danville, El Cerrito, Emeryville, a portion of Hayward, Hercules, Lafayette, Moraga, Oakland, Orinda, Piedmont, Pinole, a portion of Pleasant Hill, Richmond, San Leandro, San Pablo, San Ramon, and a portion of Walnut Creek. Brentwood is served water by contract.

Unincorporated communities served include Alamo, Ashland, Blackhawk, Castro Valley, Cherryland, Crockett, Diablo, El Sobrante, Fairview, Kensington, North Richmond, Oleum, Port Costa, Rodeo, San Lorenzo and Selby.

### Water Supply System

The Water Supply System includes a network of reservoirs, aqueducts, treatment plants, and other distribution facilities stretching from the Sierra foothills to the Bay Area. Figure I-1 is a location map of the District's major water supply facilities. These facilities include:

- Pardee and Camanche Reservoirs on the Mokelumne River.
- Three parallel aqueducts between Pardee Reservoir and Walnut Creek.
- Local raw water aqueducts and pumping plants between Walnut Creek and various terminal reservoirs and filter plants.
- Three major local terminal reservoirs.
- Six filter plants.

### Sources of Supply

#### MOKELUMNE RIVER

The District holds two water rights (License 11109 and Permit 10478), which together entitle it to divert up to 325 MGD from the Mokelumne River at Pardee Reservoir and put this water to use in portions of Alameda and Contra Costa Counties for municipal and industrial purposes. The District's entitlement to the Mokelumne River is available after the water needs of more senior right-holders have been met. Further details regarding the District's Mokelumne water rights may be found in EBMUD's Urban Water Management Plan (1985).

#### BUREAU OF RECLAMATION CONTRACT

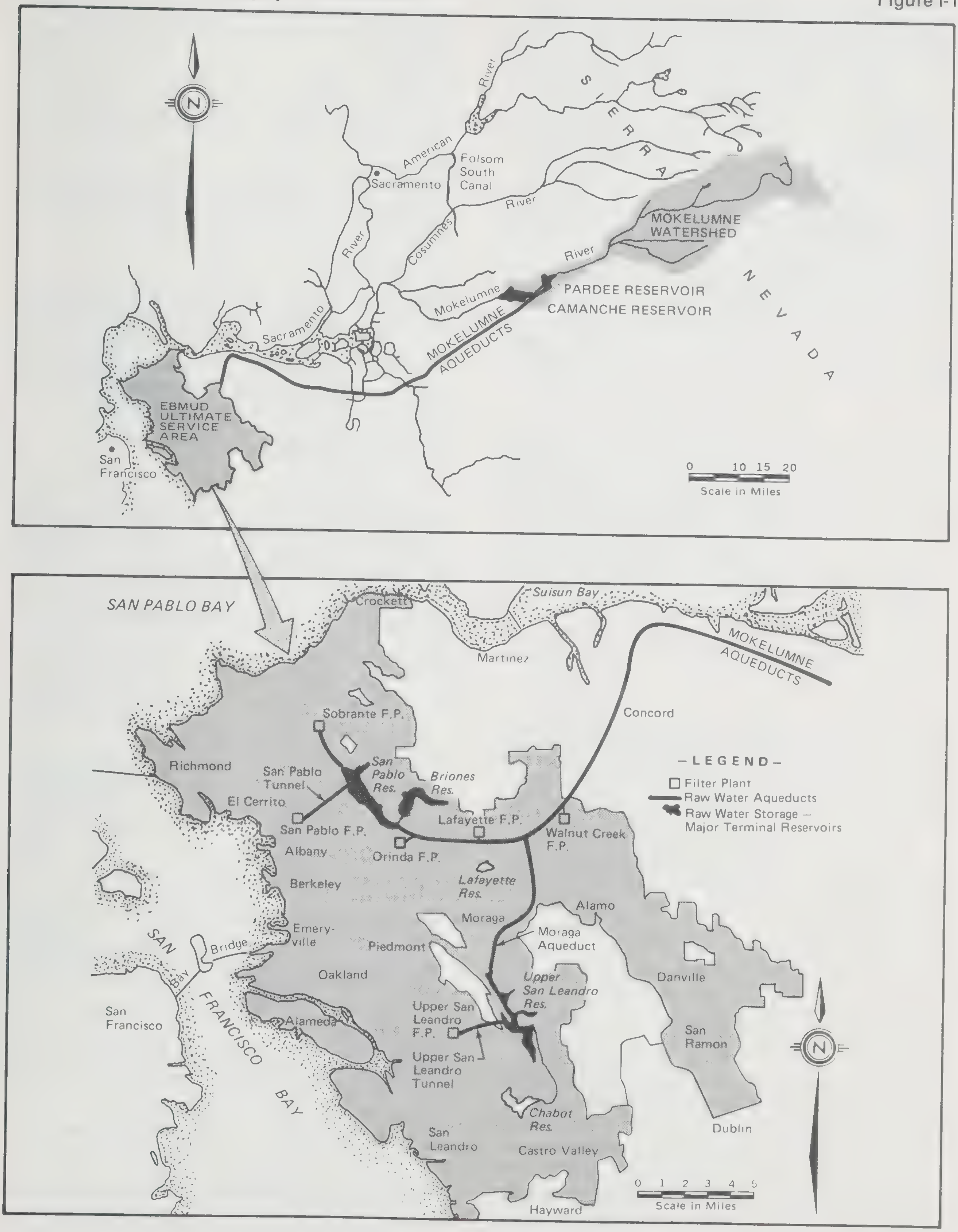
In 1970, the District contracted with the U.S. Bureau of Reclamation (USBR) for a supplemental supply of American River water from the Central Valley Project (CVP). The contract is for 150,000 acre-feet annually (AFA), or about 134 MGD. This amount, however, can be reduced by the USBR in drought years according to the contract based on estimates of available CVP water supply made by the USBR and Department of Water Resources (DWR). The point of delivery of the supplemental supply is on the Folsom South Canal near Grant Line Road, about 12 miles south of the American River. The aqueduct system necessary to convey water from the canal to the EBMUD service area is the District's responsibility, and such facilities have not yet been constructed.

In 1972, the Environmental Defense Fund, along with the Save the American River Association and others, brought suit against EBMUD. It was alleged that the delivery of American River water via the Folsom South Canal to EBMUD customers would cause severe harm to lower American River in-stream uses, and that EBMUD should take delivery of the water below the confluence of the American and Sacramento Rivers in order that beneficial uses made of water in the lower American River will not be diminished. Sacramento County joined as a co-plaintiff shortly afterward, even though the County had been represented in the negotiations which led to the signing of the 1970 contract.

**In 1984, the trial of the lawsuit was commenced in Alameda County Superior Court, and the Court referred the matter to the State Water Resources Control Board for issuance of a Report of Referee on technical questions. After an extensive**

# EBMUD Water Supply Facilities

Figure I-1



**investigation, the State Board issued its Final Report of Referee in June 1988, which supports the delivery of water to EBMUD at the turnout on the Folsom South Canal. The report also recommends that EBMUD would have to cease taking delivery of water when flows in the lower American River drop below specified minimum levels, which means that in certain dry years it could not take delivery of water.**

**The supplemental supply from the American River is not an alternative in considering the solution to the security and shortage problems faced by EBMUD. The relationship of the supplemental American River supply to the Water Supply Management Program is discussed in Chapter V in the section "Conclusions on the Most-Feasible Alternatives."**

### TERMINAL RESERVOIRS

In normal years, District reservoirs in the East Bay receive an additional 10 billion gallons of water from local watershed runoff. Much of it is captured for system use. In dry years, evaporation and other reservoir losses can exceed runoff, so there is no firm yield from local watersheds. The following sections describe the key features of the Water Supply System, starting nearest the source of supply.

### Storage - Mokelumne River

#### PARDEE DAM

Pardee Dam is located 38 miles northeast of Stockton on the Mokelumne River. The concrete gravity arch structure was completed in 1929 and rises 345 feet above the riverbed. The roadway across the dam is 575 feet above sea level and the top of the gatehouse is 598 feet above sea level. The dam is 16 thick at its crest and 239 feet thick at its base. Approximately 617,000 cubic yards of concrete were used in construction of the dam.

A 28.65 megawatt power plant at the dam generates approximately 110 million kilowatt hours per year for sale to Pacific Gas and Electric Company.

#### PARDEE RESERVOIR

Pardee Reservoir, with a capacity of 210,000 acre-feet and surface area of 2,257 acres, provides storage for municipal water supply and power generation.

#### CAMANCHE DAM

Camanche Dam, a zoned gravel structure with an impervious core, is located about 10 miles downstream from Pardee Dam on the Mokelumne River. Completed in 1964, it rises 171 feet above the riverbed and 263 feet above sea level. The spillway is 235.5 feet above sea level. The length of the crest is 2,640 feet and the dam is 34.5 feet thick at the crest and 750 feet thick at the base.

The dam and four miles of dikes contain 11.1 million cubic yards of material.

A 10.68 megawatt power plant at the dam generates approximately 40 million kilowatt hours per year for sale to Pacific Gas and Electric Company.

#### CAMANCHE RESERVOIR

Camanche Reservoir, with a capacity of 430,000 acre-feet and a surface area of 7,622 acres, provides storage for irrigation, streamflow regulation, flood control, power generation, and meeting the needs of other water rights holders. This allows EBMUD to take its full allocation out of Pardee Reservoir.

### Storage - Terminal Reservoirs

In the East Bay Hills, the District owns and operates three major terminal reservoirs: Upper San Leandro, San Pablo, and Briones. Total capacity of all the reservoirs is 155,000 acre-feet. The actual usable storage capacity is 137,500 acre-feet.

MAJOR OPERATING RESERVOIRS

- Upper San Leandro — 41,400 acre-feet
- San Pablo — 38,600 acre-feet
- Briones — 60,500 acre-feet

STANDBY STORAGE

- Chabot — 10,300 acre-feet
- Lafayette — 4,200 acre-feet

### Raw Water Aqueduct and Tunnels

Water from Pardee Reservoir moves through a tunnel about 2 miles long to the start of three Mokelumne Aqueducts at Campo Seco Center for transmission to the East Bay. All three aqueducts are steel pipelines extending about 82 miles from Pardee tunnel to the east end of the Lafayette Aqueducts in Walnut Creek. The aqueducts can deliver up to 200 MGD by gravity and up to 325 MGD by pumping. Aqueduct sizes are:

- Aqueduct No. 1 — 65 inches diameter
- Aqueduct No. 2 — 67 inches diameter
- Aqueduct No. 3 — 87 inches diameter

Lafayette Aqueduct No. 1 consists of a 9-foot circular concrete pipe and three tunnels. It extends 7.06 miles from Walnut Creek to the Orinda Filter Plant.

Lafayette Aqueduct No. 2 is a 9-foot concrete pipe with seven tunnels. It extends 7.29 miles to the Briones Diversion Works near Orinda. Here the supply can be pumped through the 7 foot-6 inch steel Briones Aqueduct into Briones Reservoir, discharged into San Pablo Reservoir, or diverted through the 7 foot-6 inch steel Orinda Raw Water Line to Orinda Filter Plant in the event the Lafayette No. 1 Aqueduct is out of service. Either or both Lafayette Aqueducts can be diverted in part at Lafayette Center to supply directly or indirectly all filter plants of the District.

### Water Treatment Plants

Water delivered to customers must pass through one of EBMUD's six operating filter plants. The total filter plant capacity is 502 MGD.

- Orinda 175 MGD
- Walnut Creek 75 MGD
- Upper San Leandro 83 MGD
- San Pablo 60 MGD
- Sobrante 60 MGD
- Lafayette 42 MGD

Orinda, Lafayette, and Walnut Creek Filter Plants normally receive water directly from the Mokelumne Aqueducts, although they may receive raw water from Briones and Lafayette Reservoirs. Mokelumne water is of very high quality, so these plants usually provide only filtration, chlorination, and fluoridation. The other three plants normally receive raw water from the terminal reservoirs. These plants therefore also provide the pre-filtration steps of aeration, flocculation, and sedimentation.

Filter plant washwater is no longer routinely discharged to streams. Instead, it is reclaimed to comply with waste discharge requirements of the San Francisco Regional Water Quality Control Board, saving up to 2 MGD of water used in treatment operations. Permanent facilities have been completed at Sobrante, Upper San Leandro and Walnut Creek Plants and temporary facilities have been constructed at Lafayette and San Pablo Filter Plants pending completion of permanent reclamation units.

### Land Use

The Utility District owns approximately 41,841 acres of watershed lands surrounding seven reservoirs with a total water surface of 12,765 acres. This land plays an important role in the protection of water quality.

The Land Use Master Plan adopted in October 1970 determines the use of the land in a manner compatible with its primary purpose as a watershed and with emphasis on preservation of open space.

The Master Plan provides 22,652 acres for watershed management, including grazing, farming and community horse pastures; 12,755 acres for recreation; 5,784 acres for educational uses; and 650 acres for various other purposes.

### Recreation

Five reservoirs are open for recreation. Briones and Upper San Leandro are not. Four of the five, Pardee, Lafayette, Chabot and San Pablo Reservoirs, store drinking water, so swimming, waterskiing, wading and similar body contact activities are not permitted. Camanche, a flood control and irrigation reservoir, is not used as a source of domestic water supply, so body contact sports are permitted there.

Pardee Reservoir was opened to the public in 1958. Lafayette, Chabot and Camanche were opened in 1966 and San Pablo in 1973.

Lafayette Reservoir is a day-use area and remains open all year. Rental rowboats, pedal boats and electric boats are available. Canoes, kayaks and small "car-top" private sailboats are allowed, but no gasoline motors are permitted. Public as well as group facilities are available on a limited basis.

Chabot Reservoir also is open all year and has facilities for boat and bank fishing, canoeing, picnicking and hiking. It is operated by the East Bay Regional Park District under a 32-year agreement that expires in 1998.

San Pablo Reservoir is open daily from mid-February to mid-November. Activities operated by a private concessionaire include excellent fishing, picnicking, boating (25 mph maximum speed) and hiking. Group picnic areas are available, as are rental rowboats, canoes and motorboats.

Since 1974, approximately 80 miles of hiking and horse-riding trails have been opened for public permit use through the East Bay watershed lands. Trail users must have valid trail permits which are available for a nominal fee at EBMUD business offices and recreation areas.

Camanche Reservoir is open all year and includes a wide variety of facilities for day and overnight use at two locations on the north and south shores. These recreation facilities are operated by private concessionaires responsible to the Camanche Regional Park Board, which leases the reservoir and most of the surrounding lands from the District. The Park Board was established in 1964 by a Joint Powers Agreements with the three host counties - Amador, Calaveras and San Joaquin - which have lease agreements with concessionaires.

Pardee Reservoir Recreation Area is open daily from mid-February to mid-November. Facilities operated by a private concessionaire include a launching ramp, overnight camping, trailer park, picnicking, boat and motor rentals, children's play area, restaurant, bait and tackle shop, and swimming pools.

# Chapter II
# Security:
# Pipe Breaks Due to Floods and Earthquakes

## BACKGROUND

### Problem

EBMUD's water supply system is subject to damage from earthquakes and floods, which can result in severance of the Mokelumne water supply. The need for increased security of the water supply facilities in the Delta was demonstrated in 1980 when Lower and Upper Jones Tracts flooded. Although the aqueducts were not damaged, the soil surrounding the support structures was partially washed away. EBMUD has studied various types of potential failures and the associated levels of risk to the water supply facilities. A review of the vulnerable areas of the raw water supply system identifies the Delta as the most critical area. There is a need to protect against extended outages caused by flood or earthquake damage in the Delta and a need to reduce the severity of rationing during an extended outage.

### EBMUD System

The source of nearly all of EBMUD's water supply is the watershed of the Mokelumne River. As shown in Figure II-1, water is stored at Pardee Reservoir before it is transported to the District's service area where it can be stored in terminal reservoirs or directly treated. Before reaching the water treatment plants, the water supply system is vulnerable to earthquakes and floods which could result in severance of Mokelumne River supplies.

Areas studied in this chapter include the Mokelumne River facilities at Pardee, the local water system in the service area, and a sixteen mile long section of the Mokelumne Aqueducts crossing the Sacramento-San Joaquin Delta. Severance of supply could cause severe water rationing for the District's customers. Figure II-2 summarizes the problems in the water supply system. There are several alternatives, as discussed in the following sections, to reduce the vulnerability of the raw water supply to outages.

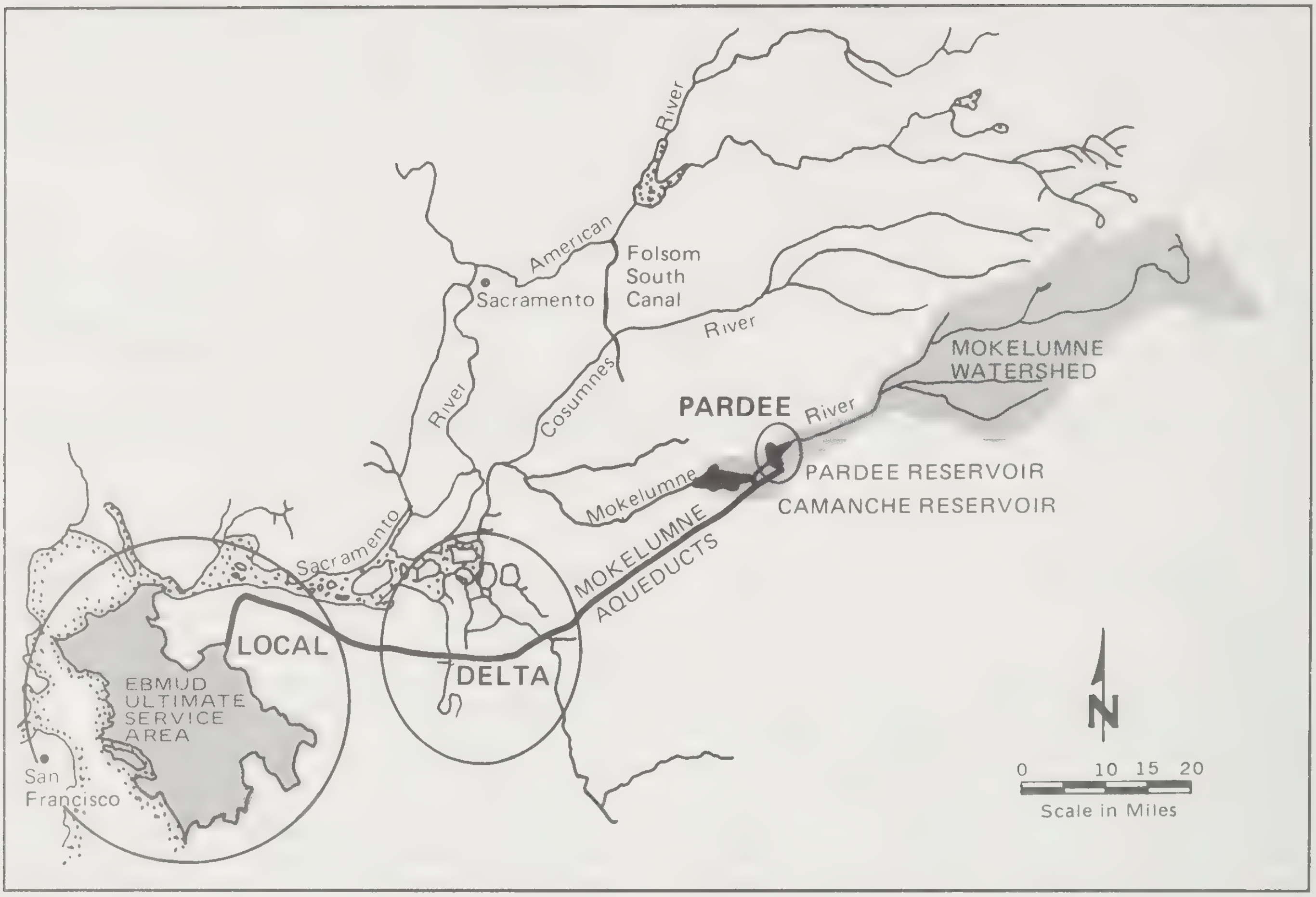
This chapter focuses on security alternatives, such as water banking (additional terminal storage to provide water during an outage); foundation improvements in the Delta, including preliminary engineering for the design of a future aqueduct; a new aqueduct across the Delta; interties with other agencies; and possible groundwater resources. The best apparent alternatives will be further evaluated in Chapter V.

### Mokelumne River Facilities at Pardee

The Mokelumne River facilities at Pardee are critical to the water supply system since all of the water from the Mokelumne River is stored at Pardee Reservoir (Figure II-3). The Pardee facilities include the reservoir, dam, outlet tower, and tunnel, which are all located within three miles of the Bear Mountain Fault Zone. The Pardee Dam is considered seismically safe and a recent study (Dames & Moore, 1987) concluded that the Pardee outlet tunnel was able to resist the maximum credible earthquake (MCE) from the Bear Mountain Fault. The MCE, defined as the maximum earthquake generated from a fault, was estimated to occur once in every 10,000 years. The study further concluded that Pardee tower could withstand moderate to high ground shaking from the Bear Mountain Fault. Damage at Pardee is not expected to produce severe rationing, and does not pose a problem to the water supply system.

## Areas of Potential Water Supply Vulnerability

Figure II-1




### Local Water Supply System

The San Andreas, Hayward, and Calaveras faults are active faults that could damage local EBMUD water supply tunnels resulting in outages. The local tunnels cross several inactive faults. While these inactive faults, which have not moved in the last 10,000 years, are not expected to produce an earthquake, they are expected to move during a major earthquake on the nearby active faults (Marliave et al., 1972). Estimates of possible damage and the water supply outage time were made to determine the vulnerability of the local water supply tunnels. The vulnerability of the tunnels is discussed below and the tunnels are shown in Figure II-4.

Studies to estimate the potential earthquake damage and corresponding repair times for various tunnels were performed by Marliave et al., 1972; F.P. Bystrowski & Co., 1972; and Woodward-Lundgren & Associates, 1974. These studies concluded that earthquakes would cause only minor damage to reinforced tunnels constructed in bedrock (Pleasant Hill Tunnels, Walnut Creek Tunnel No. 2, and Lafayette Tunnel No. 2) and that these water supply facilities would remain operational until repairs could be made.

The studies also estimated that earthquakes may cause significant damage to unreinforced and reinforced tunnels constructed in alluvial material (Walnut Creek No.1, Lafayette No.1, San Pablo, and San Leandro Tunnels). Although significant earthquake damage may not cause complete and immediate tunnel closure, the amount of water flow would be restricted.

The amount of damage will depend on the geology and structural adequacy of each tunnel. Estimates of the outage time required for tunnel repairs were based on a 24 hour workday, 7 days per week, from the time of tunnel closure to tunnel restoration. The outage times vary from 30 to 180 days as follows:

- 30 days for Walnut Creek Tunnel No. 1
- 30 days for Walnut Creek Tunnel No. 2
- 180 days for Lafayette Tunnel No. 1
- 60 days for Lafayette Tunnel No. 2
- 30 days for Pleasant Hill Tunnels Nos. 1 & 2
- 120 days for San Pablo Tunnel
- 120 days for San Leandro Tunnel

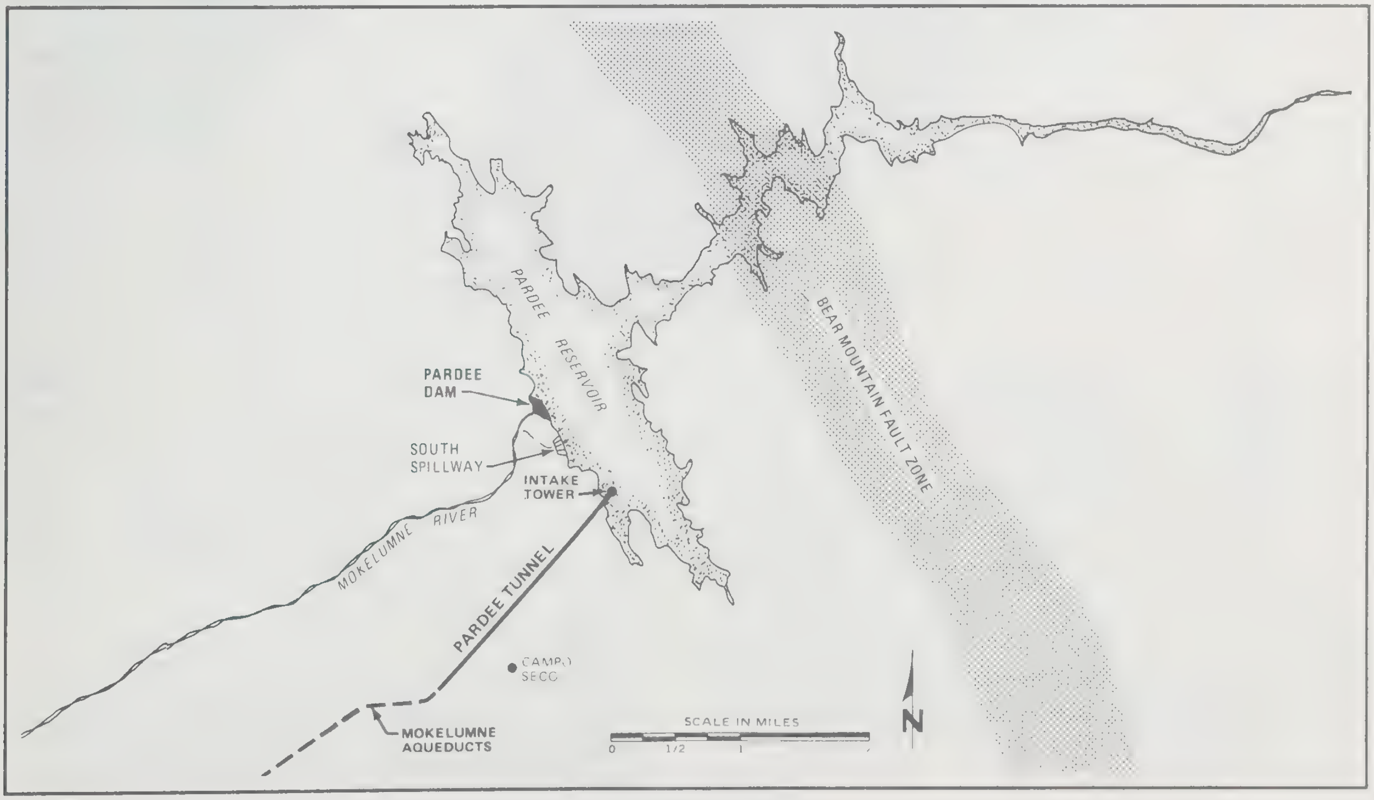
## Summary of Potential Problems in the Water Supply System

Figure II-2

| | PARDEE DAM | LOCAL RAW WATER SYSTEM (Terminal Reservoirs, Aqueducts and Tunnels) | MOKELUMNE AQUEDUCTS IN THE DELTA |
|---|---|---|---|
| EARTHQUAKES | No damage from earthquakes with recurrence intervals of less than once in 250 years. | Damage may be caused by high to very high ground movement. | **Very high ground shaking:**<br>Extensive levee failure.<br>All Islands and tracts flooded.<br>Entire 16 miles of aqueducts damaged.<br>Salinity up to 2,600 mg/L at Rock Slough. |
| | | | **High ground shaking:**<br>Levee breaks at many locations.<br>More than three islands flooded.<br>Elevated Aqueduct #1 destroyed<br>Four miles each of Aqueducts #2 & 3 damaged.<br>Salinity up to 2,600 mg/L at Rock Slough. |
| | | Damage unlikely due to low to moderate ground movement. | **Low/moderate ground shaking:**<br>Levee breaks at several locations.<br>One or more islands flooded.<br>Elevated Aqueduct #1 extensively damaged.<br>Up to 2 miles each of Aqueducts #2 & 3 damaged.<br>Salinity up to 1,000 mg/L at Rock Slough. |
| FLOODS | No damage due to floods | Damage unlikely due to floods. | **Flood due to overtopping and instability:**<br>Scour from flow through break undermines piles.<br>All aqueducts next to break scour damaged.<br>Up to 750' of each aqueduct damaged.<br>One or more islands or tracts flooded.<br>Salinity up to 2,600 mg/L at Rock Slough. |

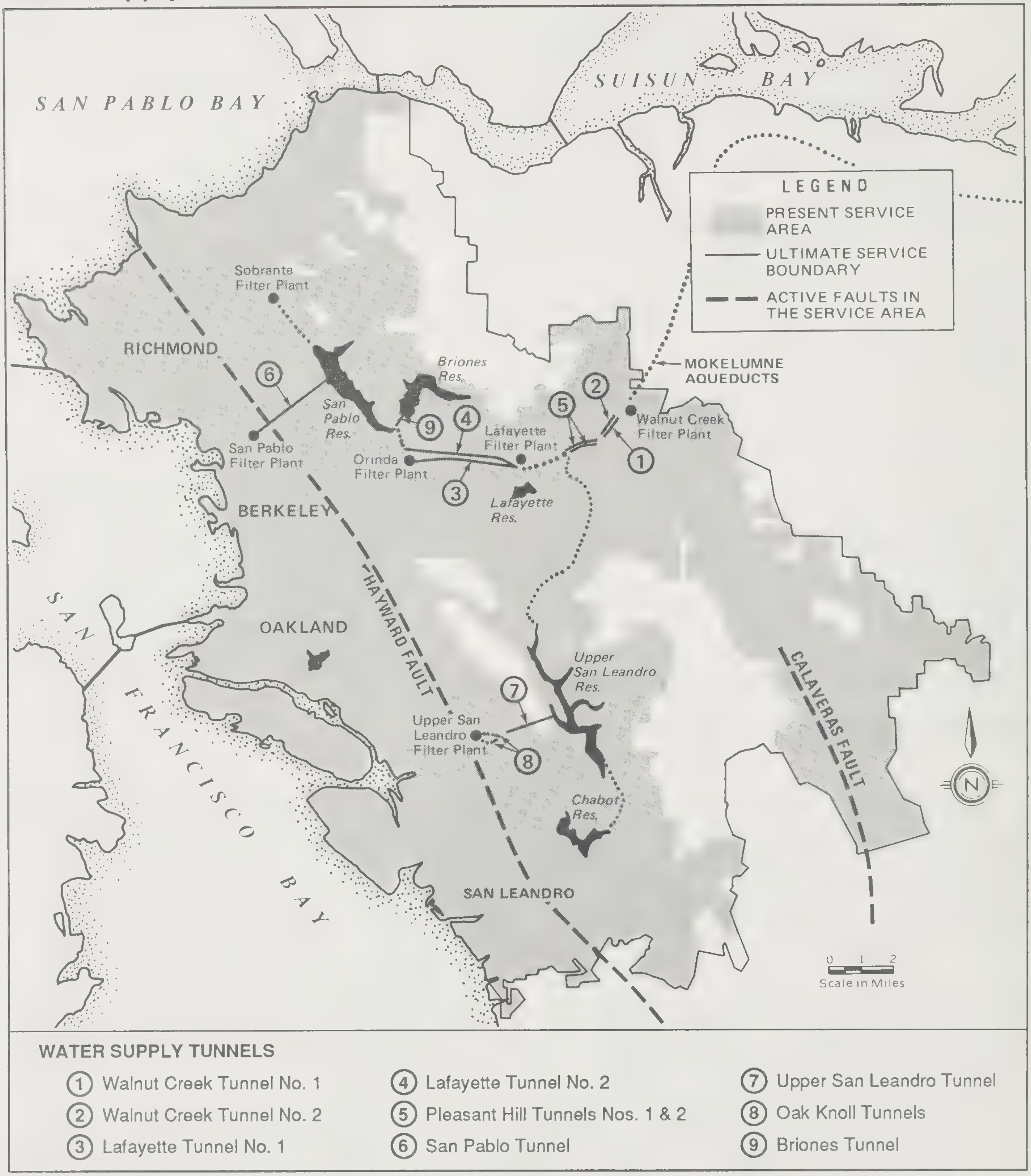
## Pardee Reservoir

Figure II-3



## Water Supply Tunnels in the Local Service Area

Figure II-4




- 90 days for Oak Knoll Tunnels (between San Leandro Tunnel and San Leandro Filter Plant)
- 180 days for Briones Tunnel.

Terminal reservoirs provide standby storage in case of such an outage. EBMUD currently tries to maintain a minimum of 120 days of standby supply to be able to respond to short-term supply disruptions. The 120-day

supply is based on the time needed to repair potential tunnel outages and is required as standby for a third year drought.

The raw water tunnels from the terminal reservoirs to the water treatment plants are also susceptible to outages. Although closure of a reservoir outlet tunnel could isolate the terminal reservoir, areas normally served by an isolated reservoir can still be served by another reservoir. For example, the area served by Upper San Leandro Reservoir can also be served by Briones Reservoir in the event of damage to the Upper San Leandro or Oak Knoll Tunnels. In the event of damage to the San Pablo Tunnel, customers served by San Pablo Reservoir can still be served by the Sobrante Filter Plant. In summary, the District maintains a 120-day standby supply to meet short-term outages in the local raw water supply system.

EBMUD's existing dams in the service area have recently been evaluated by independent consultants and subsequently modified to resist maximum credible earthquakes to meet the California Division of Safety of Dams safety requirements. Any new dam would be designed to meet the latest safety standards which currently require a dam to withstand a maximum credible earthquake.

## Delta

The Sacramento-San Joaquin Delta (Delta) comprises about 750,000 acres with more than 60 islands and tracts formed by 1,100 miles of levees. The tributary rivers and streams supply fresh water that passes through 600 miles of waterways and eventually out of the Delta. The fresh water pushes back the sea water from Suisun Bay. As shown in Figure II-5, the Sacramento River enters the Delta from the north and the San Joaquin River enters from the south and divides into three channels within the Delta: the San Joaquin, Old, and Middle Rivers. Rivers entering from the east include the Mokelumne, Calaveras, and Cosumnes. Exports of Delta water for municipal, industrial, and agricultural usage include: flows to South San Francisco Bay, Southern California and San Joaquin Valley via the state's Harvey O. Banks (Delta) Pumping Plant and the federal Tracy Pumping Plant, both located at the southern end of the Delta; and flows to the Contra Costa Water District (CCWD) service area via CCWD's pumping plant at Rock Slough located in the western end of the Delta.

In terms of EBMUD's water supply system, the Delta is the most critical area because floods and earthquakes could cause severe water supply outages. The Delta is comprised of an extensive system of levees, which are not designed to resist major flooding and earthquake forces. Levee failure and subsequent flooding could lead to aqueduct damage. Furthermore, Delta water quality can be severely degraded during the flooding of an island, making the Delta unreliable as a source of emergency water. This section reviews potential risks to EBMUD facilities in the Delta, provides background information relating to the Mokelumne Aqueducts, and discusses the involvement by EBMUD, state, and federal agencies to improve the levees and the quality of Delta water.

### POTENTIAL RISKS TO EBMUD FACILITIES IN THE DELTA

The need for increased security for EBMUD water supply facilities in the Delta was made clear in 1980 when Lower and Upper Jones Tracts flooded. The railroad embankment adjacent to the Mokelumne Aqueducts subsequently failed, allowing flood waters to flow into Upper Jones Tract, inundating the tract crossed by more than 5 miles of the aqueducts, as shown in Figures II-6 and II-7.

Although the pipelines did not break, there was deep scour, which almost undermined the pipes' support structures. Two fortuitous circumstances contributed to the survival of the pipelines: The flow through the break was reduced by the low water level on Lower Jones Tract and was deflected by two locomotives and a box car that fell off the railroad embankment.

The 1980 flood accelerated EBMUD studies and investigations of the types of potential aqueduct failures and associated levels of risk of various magnitude earthquakes and potential Delta levee failures caused by floods. The results of these investigations are described in later sections of this chapter.

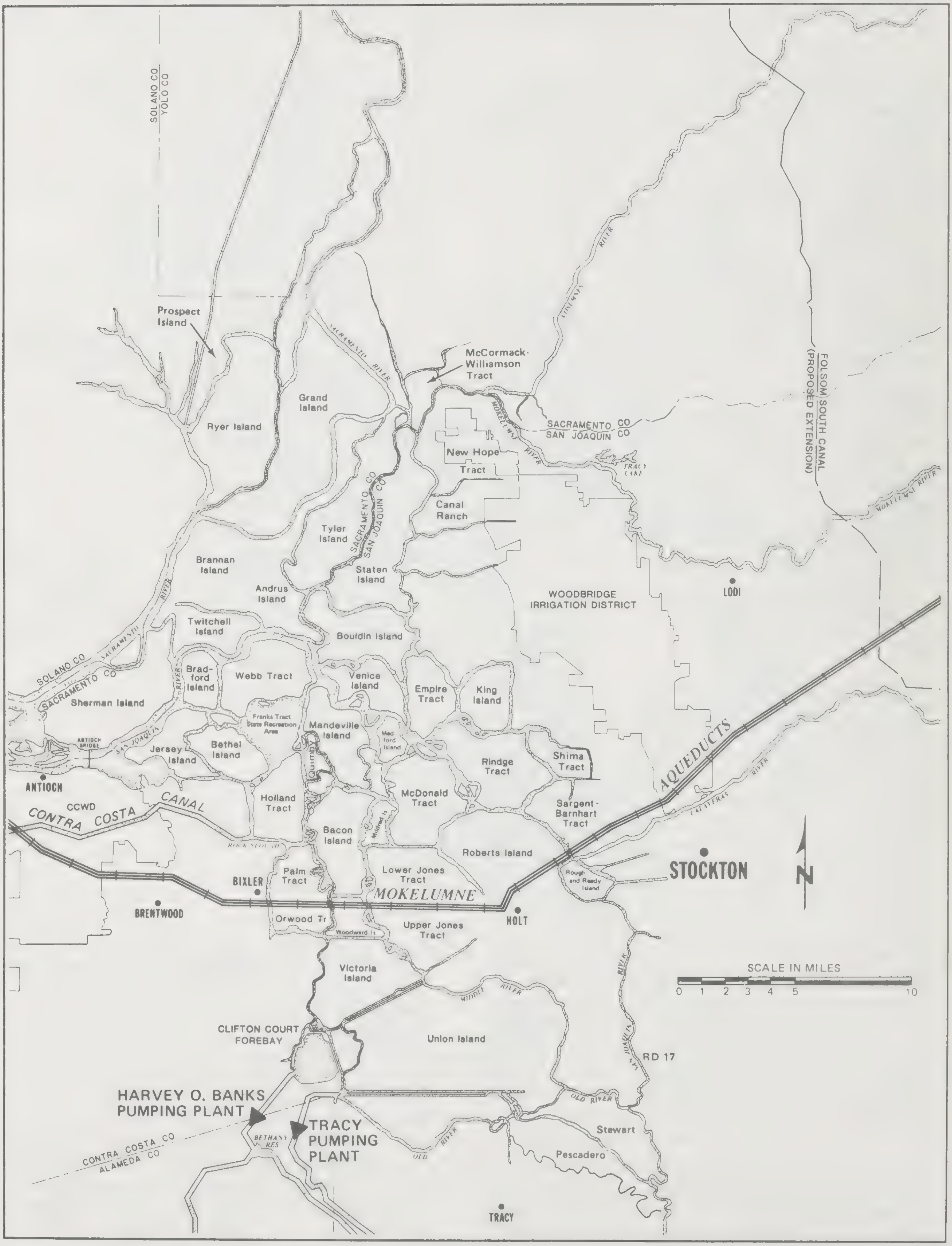
### THE MOKELUMNE AQUEDUCTS IN THE DELTA

The Mokelumne Aqueducts were not designed to resist flooding or earthquake forces in the Delta. Severe damage may occur with long durations of water supply outage. This section discusses the inadequate support structure of the aqueducts and soil conditions in the Delta.

The Mokelumne Aqueduct system crosses the Delta in three parallel pipelines. Aqueducts Nos. 1,2, and 3 were constructed in 1928, 1949, and 1963 with inside diameters of 65, 67, and 87 inches, respectively. Aqueduct No. 1 is supported by concrete bents on wood piles and Nos. 2 and 3 by steel bents on concrete piles.

## Sacramento-San Joaquin Delta

Figure II-5

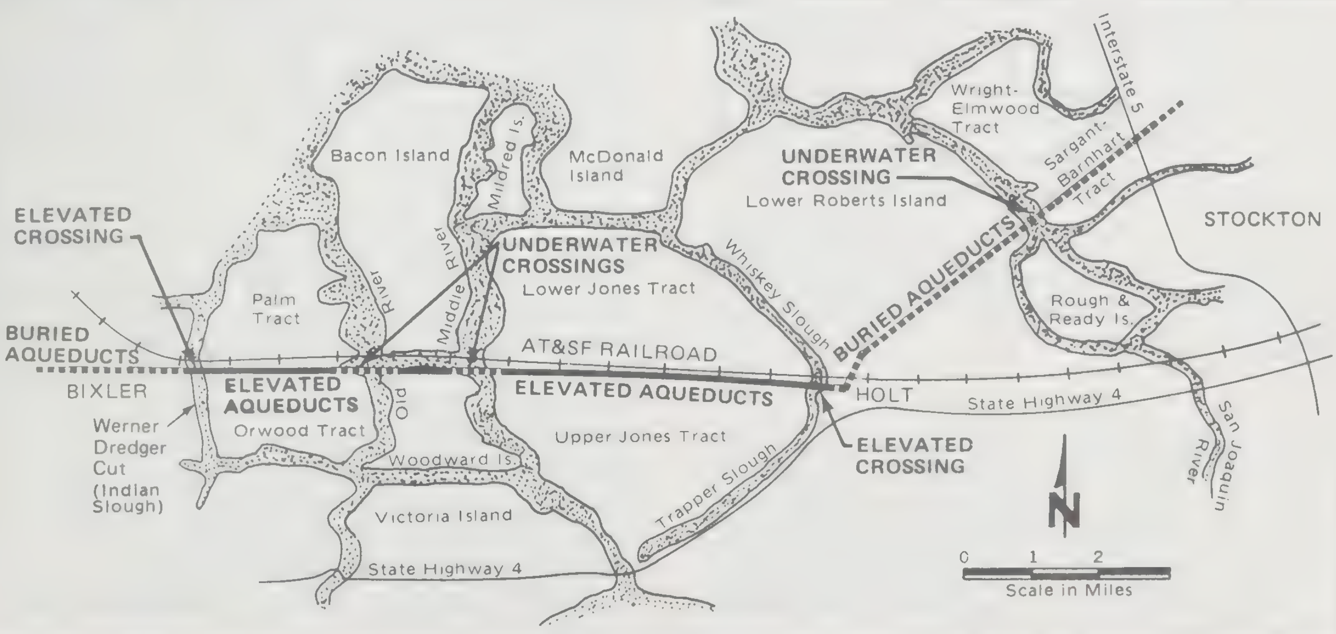


## 1980 Upper Jones Tract Flood

Figure II-6

## Mokelumne Aqueducts Across the Delta

Figure II-7



The aqueducts enter the vulnerable portion of the Delta west of the City of Stockton, about 3,000 feet west of Interstate Highway 5 (on Sargent-Barnhart Tract), and exit the Delta 2,000 feet west of Indian Slough (on Upper Orwood Tract), as shown in Figure II-7. The Mokelumne Aqueducts cross about 16 miles of the Delta, with about 60 percent elevated and the remaining 40 percent buried including three underwater crossings, as indicated in Figure II-8.

**Aqueduct Support Structure.** The support systems for the elevated aqueduct sections are shown schematically in Figure II-9. The piles of Aqueduct No. 1's support are not able to resist even moderate earthquake forces. Aqueduct No. 1 is supported by wooden cradles resting on concrete bents, which are supported by timber piles. The timber piles are untreated and the 1981 Converse study revealed that substantial rot and decay has occurred, and the condition will worsen. The bent structures are connected to the timber piles with metal pins affected by both external and internal timber rot. Rot damage has also occurred to the timber piles near the pile/bent support and pile/anchor structure connections.

Dynamic analyses show the piles in their present condition to be susceptible to potential damage as result of seismic loading at low levels of shaking (0.1 to 0.15g). At moderate levels of ground acceleration (0.15 to 0.2g), Aqueduct No. 1 will have extensive damage or may fail due to the deteriorated condition of the tops of the wood piles and sliding of the wood cradles supporting the pipe itself.

The support system for the elevated portions of Aqueducts Nos. 2 and 3 have a sling and steel frame bent structure which provides the pipelines with adequate support during low to moderate ground shaking. However, none of the aqueducts are attached to their supports and could float free if submerged in a flood. During the past 60 years, no earthquake-induced failure has occurred in the Delta since the Mokelumne Aqueducts have been in service.

Sections of the aqueducts in the Delta are buried. Both the elevated and buried portions of the aqueducts are susceptible to damage as a result of levee failure from earthquakes and floods.

**Existing Levees.** Figure II-10 illustrates the cross-section of a typical levee. The islands in the Delta all have ground surface elevations below mean sea level and are protected from flooding by levees. These levees are typically not engineered embankments, but are simply composed of fill dredged from adjacent channels and piled along the sides.

Foundation soil for both the levees and the aqueduct pipelines are composed of peat and loose sandy silt. The weak and highly compressible fibrous organic peat is the primary reason for levee settlement and the main cause of overall settlement of the entire central Delta region. The continued settlement of the Delta islands has increased the risk of levee failures and has made levee integrity vital to the operation of the Mokelumne Aqueducts. Loose sands, also located in the foundation soil, are vulnerable to earthquake-induced liquefaction (a quick-sand condition) that could result in support failure for levees and pipelines.

## PAST IMPROVEMENTS IN THE DELTA

To reduce the likelihood of severe rationing and economic impact to EBMUD customers during an outage, the District has implemented several measures to improve the security of the aqueducts. These measures followed the near failure of the Mokelumne Aqueducts during the Lower Jones Tract levee and railroad embankment failures in 1980 and include levee inspection and monitoring ($0.9 million, 1982-1987), stockpiling of aqueduct pipes ($0.6 million, 1982), and assistance to island reclamation districts for levee improvements ($1.3 million, 1981-1987). Although EBMUD has no direct authority over the Delta levees, it voluntarily monitors and regularly inspects levees protecting the aqueducts, especially during periods of high tidal stages or flood flows.

The District has purchased 1,500 feet of aqueduct pipe and fittings. The materials are stockpiled at Bixler to permit quick repair of the failed aqueduct sections in the Delta. Damage to the aqueducts due to moderate ground shaking will require miles of pipeline, much more than the amount of stockpiled pipe for minor repairs. Stockpiling additional pipeline would not reduce the time required to repair massive earthquake damage to the aqueducts, because the fabrication and delivery of pipe is not on the critical path to the repair time of the aqueducts.

To reduce the risks of levee failure on the islands along or adjacent to the aqueduct alignment, the District has given financial assistance to the reclamation districts on Woodward Island, Orwood Tract, and Upper Jones Tract to widen and raise the levee crest. The expenditures have been shared by EBMUD and the reclamation districts. The State reimburses portions of the expenditures to the reclamation districts for further levee maintenance and improvements. Beginning in the fiscal year 1981-1982 and ending in fiscal year 1986-1987, the expenditures for levee repairs (before reimbursements) are shown in Figure II-11.

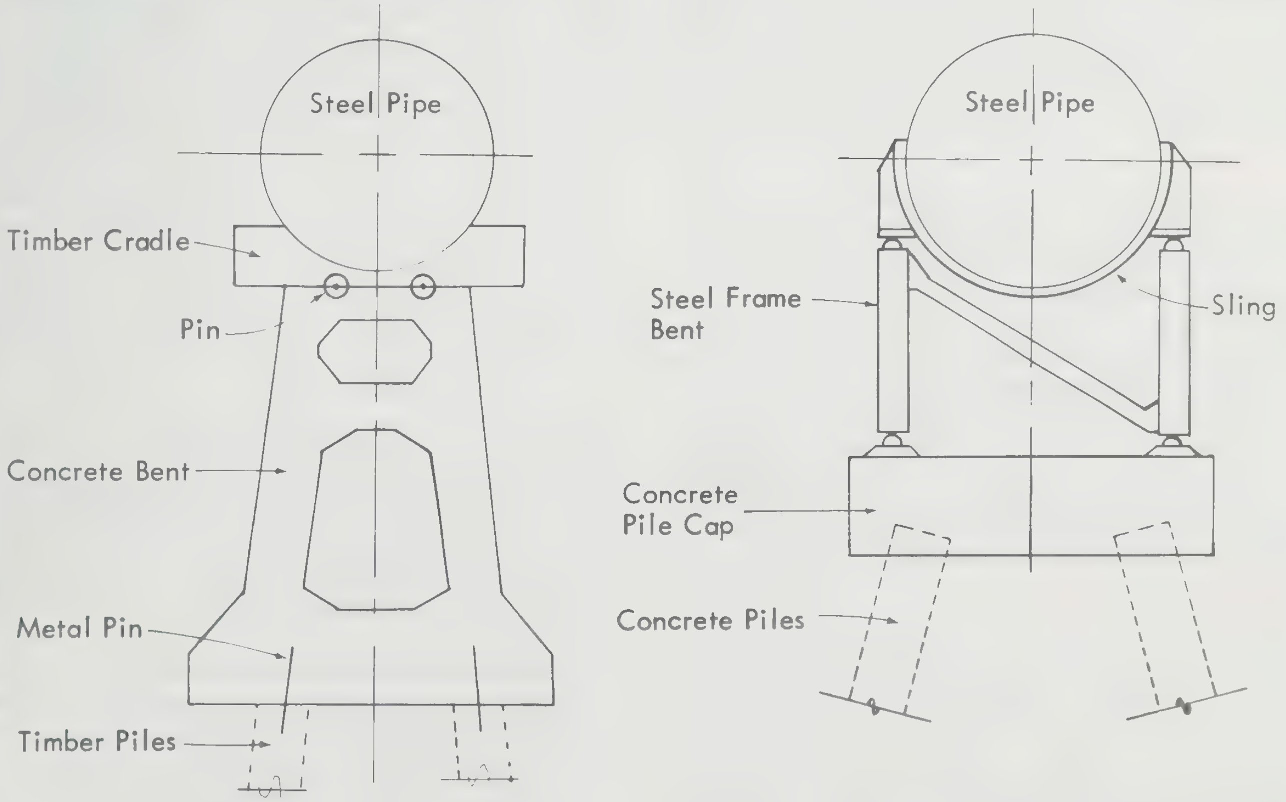
## Mokelumne Aqueducts in the Delta Area

Figure II-8

| REACH | CONFIGURATION LENGTH, MILES | | | |
|---|---|---|---|---|
| | ELEVATED | BURIED | UNDERWATER CROSSING | TOTAL |
| Sargent-Barnhart Tract | 0.0 | 1.3 | | 1.3 |
| San Joaquin River | | | 0.2 | 0.2 |
| Lower Roberts Island | 0.6 | 3.5 | | 4.1 |
| Trapper Slough | 0.3 | 0.0 | | 0.3 |
| Upper Jones Tract | 5.0 | 0.2 | | 5.2 |
| Middle River | | | 0.2 | 0.2 |
| Woodward Island | 1.1 | 0.4 | | 1.5 |
| Old River | | | 0.1 | 0.1 |
| Orwood Tract | 2.3 | 0.3 | | 2.6 |
| Upper Orwood Tract | 0.1 | 0.3 | | 0.4 |
| TOTAL | 9.4 | 6.0 | 0.5 | 15.9 |

## Elevated Aqueduct Supports

Figure II-9

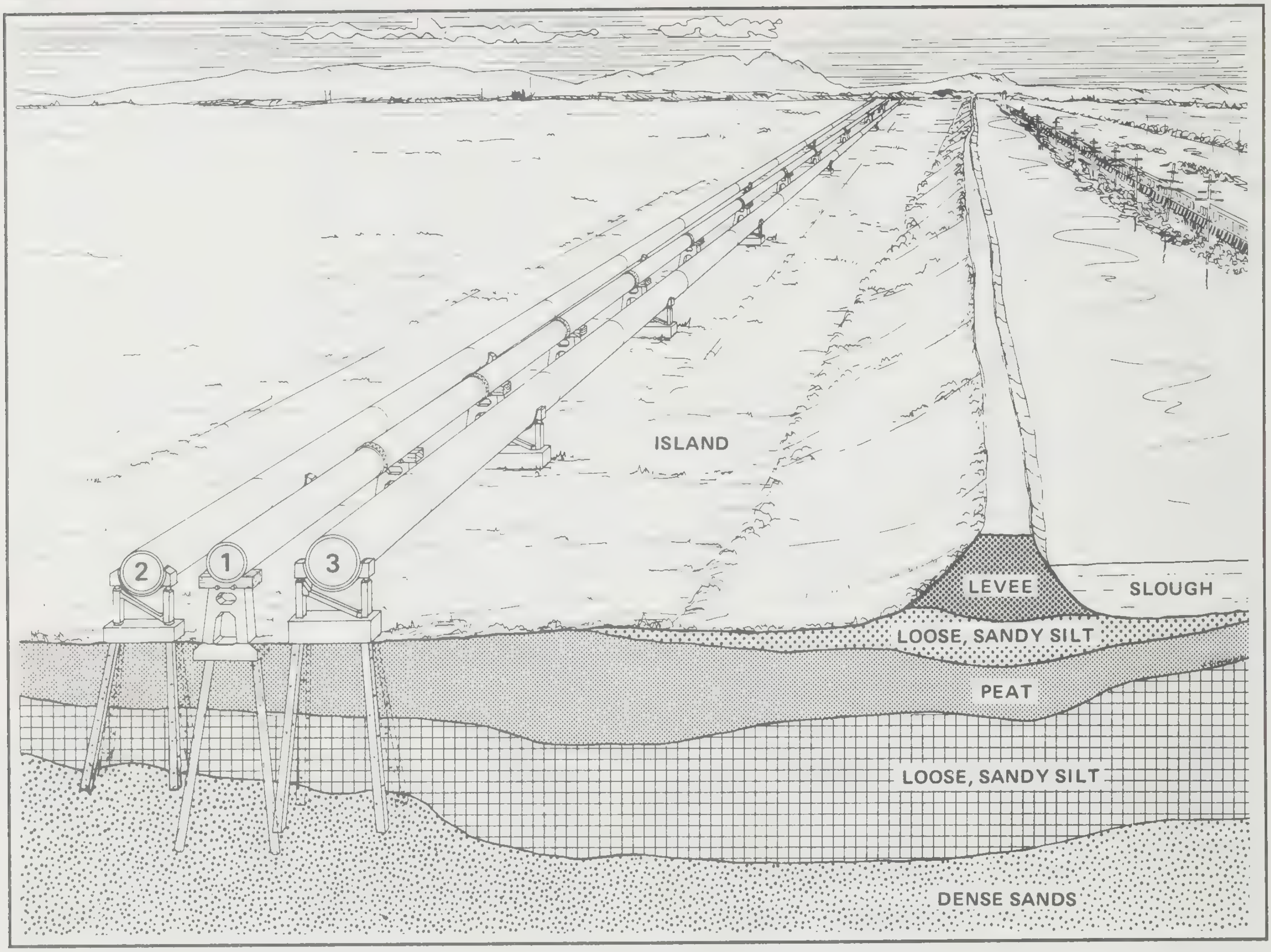



AQUEDUCT NO. 1

AQUEDUCTS NO. 2 AND 3

## Subsurface Soil Horizons in the Delta

Figure II-10




## Levee Repairs and Improvements (1981 to 1987)

Figure II-11

| LOCATION | EBMUD* ($ Millions) | RECLAMATION DISTRICTS** ($ Millions) |
|---|---|---|
| Woodward Island | 0.8 | 1.2 |
| Orwood Tract | 0.3 | 0.4 |
| Upper Jones Tract | 0.2 | 0.3 |
| TOTAL | 1.3 | 1.9 |

*Reflects expenditures for improvements made on Delta islands/tracts crossed by the Mokelumne Aqueducts.
**State reimbursement of $0.7 million has been spent on levee improvements.

OUTSIDE AGENCY INVOLVEMENT IN DELTA RECLAMATION

Past studies by state and federal agencies were made to improve levee integrity and water quality in the Delta. Both the U.S. Bureau of Reclamation (USBR) and the Department of Water Resources (DWR) depend on the integrity of the Delta levees to insure the export of acceptable quality water. The following sections will discuss the studies.

**California's Department of Water Resources Recommendations.** A recent study (DWR, 1986) recommended a course of action in the event of a Lower Jones Tract flooding with damage to the Mokelumne Aqueducts. The study recommended that export of water at the Delta and Tracy Pumping Plants be halted or reduced; upstream releases be increased to augment the freshwater flow into the

Delta; and emergency interconnections from other water agencies be established to provide EBMUD with water supplies. The study did not determine if sufficient water supplies with adequate water quality would be available if an outage were to occur.

**Interagency Delta Management Committee.** Two recent studies of the Delta, (U.S. Corps of Engineers, COE, 1982) (DWR, 1982) identified serious levee problems and recommended various levels of improvements. These studies concluded that two islands crossed by the Mokelumne Aqueducts, Upper Orwood and Woodward Islands, have a high probability of levee failure. The improvements to the levees since the studies have reduced the risks of flooding.

**Emergency Delta Task Force.** In January 1982, the State Assembly created an advisory panel, the Emergency Delta Task Force, to: propose a levee restoration plan for non-project levees; develop a cost sharing formula, and review the COE and DWR plans for Delta levee restoration. The Task Force recommended immediate erosion protection for Woodward, Lower and Upper Jones, and Lower, Middle and Upper Roberts Islands and immediate major structural improvements for Woodward Island. The Task Force also recommended erosion protection and major structural improvements for Jones, Roberts, Orwood, and Sargent-Barnhart Islands within the next 10 years. The proposed plan was estimated to cost about $35 million in 1982 prices.

**Way-Mobley Act.** In 1973 the State Legislature enacted the Way-Mobley Act, which established a program to assist Delta levee districts with levee restoration. The funding for this program has been about $2 million per year. In 1988, legislation (SB 34, Boatwright) increased this to $12 million per year for the next 10 years.

## PRESENT AND FUTURE NEEDS

Damages to the Mokelumne Aqueducts in the Delta from earthquakes or flooding could result in a complete outage of the Mokelumne water supply for an extended period, which will be discussed in the Risk of System Failure section of this chapter. EBMUD customers could experience adverse impacts of severe water rationing caused by extended outages and the lack of adequate storage. EBMUD has established measures to respond to the threat of outages with assistance to island reclamation districts for levee improvements, levee inspection and monitoring, and stockpiling of aqueduct pipes for minor repairs. The present measures do not eliminate the threat of severe rationing during an extended outage. Risk of outages can be reduced by water banking (additional terminal storage) or by upgrading existing facilities as described in the Alternatives section of this chapter.

EBMUD's goal has been to protect its customers from severe rationing. A 13 month long water supply outage in 2020 would cause rationing (deficiency) of up to 69 percent with the existing terminal storage. Additional storage of 100,000 acre-feet and 145,000 acre-feet will reduce rationing to 39 percent and 25 percent, respectively. A discussion of the current and future levels of rationing will be addressed in Chapter III. The following sections will discuss the risks of the water supply system failure and the impact of system failure on the customer.

### Risk of System Failure

As shown in Figure II-2, the existing water supply is vulnerable to two major natural disasters: earthquakes and floods. The Pardee Reservoir dam, outlet tower, and tunnel are expected to survive earthquakes and floods without any interruption in service. Flooding is not expected to affect the local water system, which may, however, be affected by earthquakes. Nevertheless, the risk of a supply outage in the local system is small because damaged sections can be bypassed until repairs can be completed. The risk of damage to the Mokelumne Aqueducts in the Delta, the resulting water supply outages, and the impacts of Delta water quality on EBMUD customers will be discussed in the following sections.

#### RISKS IN THE DELTA

The Mokelumne Aqueducts in the Delta are vulnerable to potential damage from both earthquakes and floods. Outages occurring from scour caused by floods are estimated to last up to 4 months (EBMUD, Addendum, 1982). Outages lasting 4 months can be served by the 120-day standby supply available in existing terminal storage. However, earthquake damage in the Delta from relatively frequent high level ground shaking can cause a 13-month outage of the water supply. Very high level ground shaking can cause up to a 17-month outage. The various outage times associated with the levels of damage are shown in Figure II-12.

**Threat of Flooding Near Aqueducts.** Flood and tide stage-frequency relationships, based on measurements of 24-stage gages throughout the Delta, were developed by the COE. The COE data was used to calculate annual flood stage probabilities for the individual islands along the aqueduct route (COE, 1976). Probabilities of levee failure were based on the expected future subsidence of the Delta, the conditions of the levee, and the COE data (Converse, 1981).

## Types of Aqueduct Failure in the Delta

Figure II-12

| EVENT | ESTIMATED DAMAGE | OUTAGE** |
|---|---|---|
| **EARTHQUAKE** | | |
| Very high level of ground shaking (greater than 0.25g)* | Extensive levee failure and all islands and tracts flooded.<br>Elevated aqueducts completely collapsed.<br>Extensive damage to all buried pipelines and river crossings. | Up to 17 months |
| High level of ground shaking (0.2 to 0.25g)* | Levee breaks at many locations and most islands flooded.<br>Elevated No. 1 Aqueduct completely collapsed.<br>Elevated No. 2 and No. 3 aqueducts collapsed at several locations.<br>Breaks in buried pipelines at several locations.<br>Extensive damage to pipelines at one or more river crossings. | Up to 13 months |
| Low to moderate ground shaking (0.1 to 0.2g)* | Levee breaks at several locations and one or more islands or tracts is flooded.<br>Elevated No. 1 Aqueduct extensively damaged.<br>Elevated No. 2 and No. 3 Aqueducts damaged at a few locations.<br>Possible breaks in buried pipelines.<br>Some damage to pipelines at one or more river crossings. | Up to 10 months |
| **FLOOD** | | |
| Single break near elevated aqueducts | Levee break at one or more locations.<br>Scour from flow through levee undermines pile supports.<br>One or more aqueducts opposite the break are damaged.<br>The island or tract is flooded. | Up to 4 months |

*Based on technical studies by independent consultants of ground acceleration due to an earthquake.

**Outage means severance of Mokelumne River water supply.

**Earthquake Faults Threatening the Delta.** Although the 1906 earthquake damaged portions of the Delta, no earthquake-induced failure has occurred in the Delta during the 60 years that the Mokelumne Aqueducts have been in service. Seismic experts find the lack of high or very high ground shaking since 1906 unusual. The probability of relatively low level of ground motion may be best determined by the number of prior events, while high shaking levels may be determined by the physical characteristics of the earthquake faults. The period from 1906 to 1979 has been seismically quiet compared to a volatile period from 1830 to 1906 which contained several large seismic events, as shown in Figure II-13.

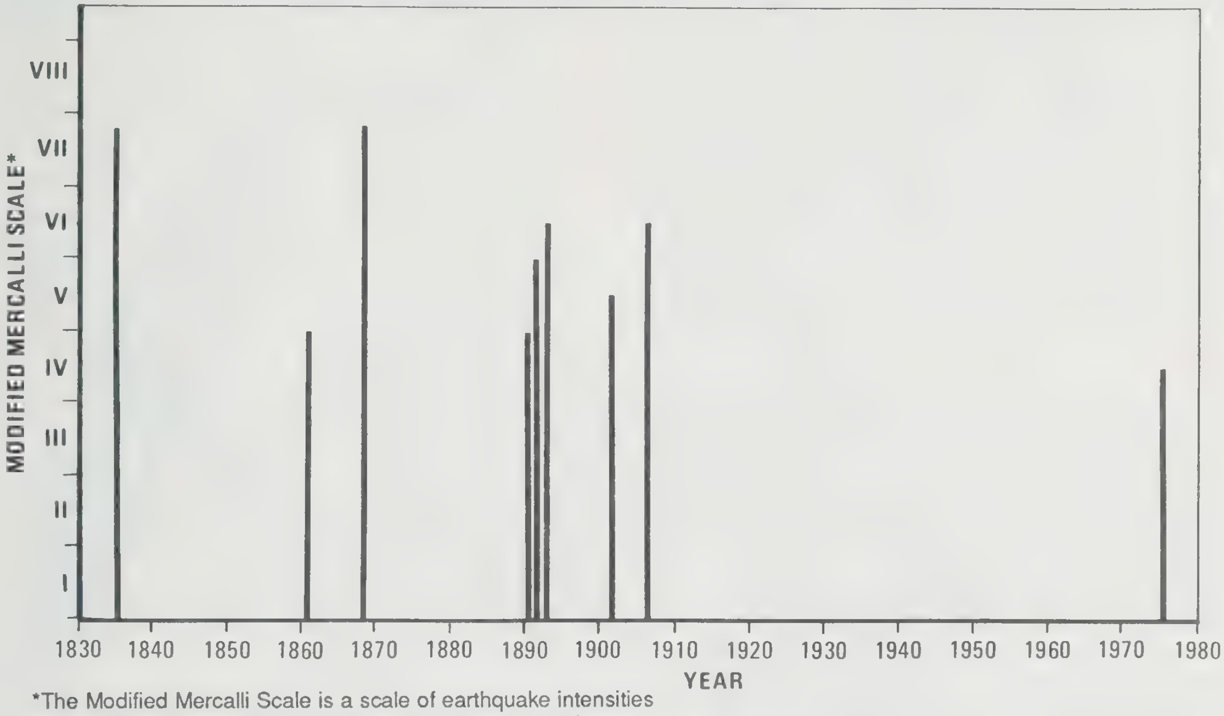
It should be noted that any estimates of future earthquakes affecting the Delta must contain considerable uncertainties because the historic data are limited. The period since 1906 is considered atypical of the long-term seismicity of the region. The recurrence interval of a major earthquake event is a statistical average over a long time period. An earthquake is not expected to occur every recurrence interval. However on the average, one earthquake should occur for each recurrence interval. Under these circumstances, it may be unwise to base arguments entirely on what has happened in terms of damage to the existing aqueducts.

As shown in Figure II-14, twelve active faults, which could create damaging ground shaking, have been identified within 50 miles of the Delta region. Three major fault systems (the Calaveras, Hayward, and San Andreas Faults) run north to south in the area west of the Delta and are capable of producing earthquakes with a maximum Richter magnitude up to 8.5. In comparison, the 1906 earthquake from the San Andreas Fault that devastated San Francisco had a Richter magnitude of 8.3. Nine additional north-south faults, located between 10 and 40 miles from the Delta, are capable of producing 6 to 6.5 Richter magnitude earthquakes.

The damage to the aqueducts from earthquakes is caused by the actual ground motion in the Delta. For example, the relatively small Antioch Fault (located

## History of Earthquake Intensities in the Delta Study Area

Figure II-13




*The Modified Mercalli Scale is a scale of earthquake intensities ranging from I to XII, with XII representing the greatest damage.

Source: Bolt, Jan. 1977

closest to the Mokelumne Aqueducts) is capable of generating a 6.5 Richter magnitude earthquake, with high to very high levels of ground motion in the Delta. The remaining eleven faults, including the San Andreas, Hayward and Calaveras Faults, may generate even greater magnitude earthquakes than the Antioch. However, these eleven faults would cause a lower level of ground shaking (acceleration up to 0.2g) due to their greater distance from the Delta.

Historic earthquakes within 75 miles of the Delta area were used to calculate the recurrence relationship represented by the upper portion of the shaded area in Figure II-15. The physical characteristics of earthquake faults west of the Delta area were used to calculate the recurrence relationship represented by the lower portion of the shaded area. The solid line represents the judgement of expert seismologists as a compromise between the two methods.

POSSIBLE DAMAGE

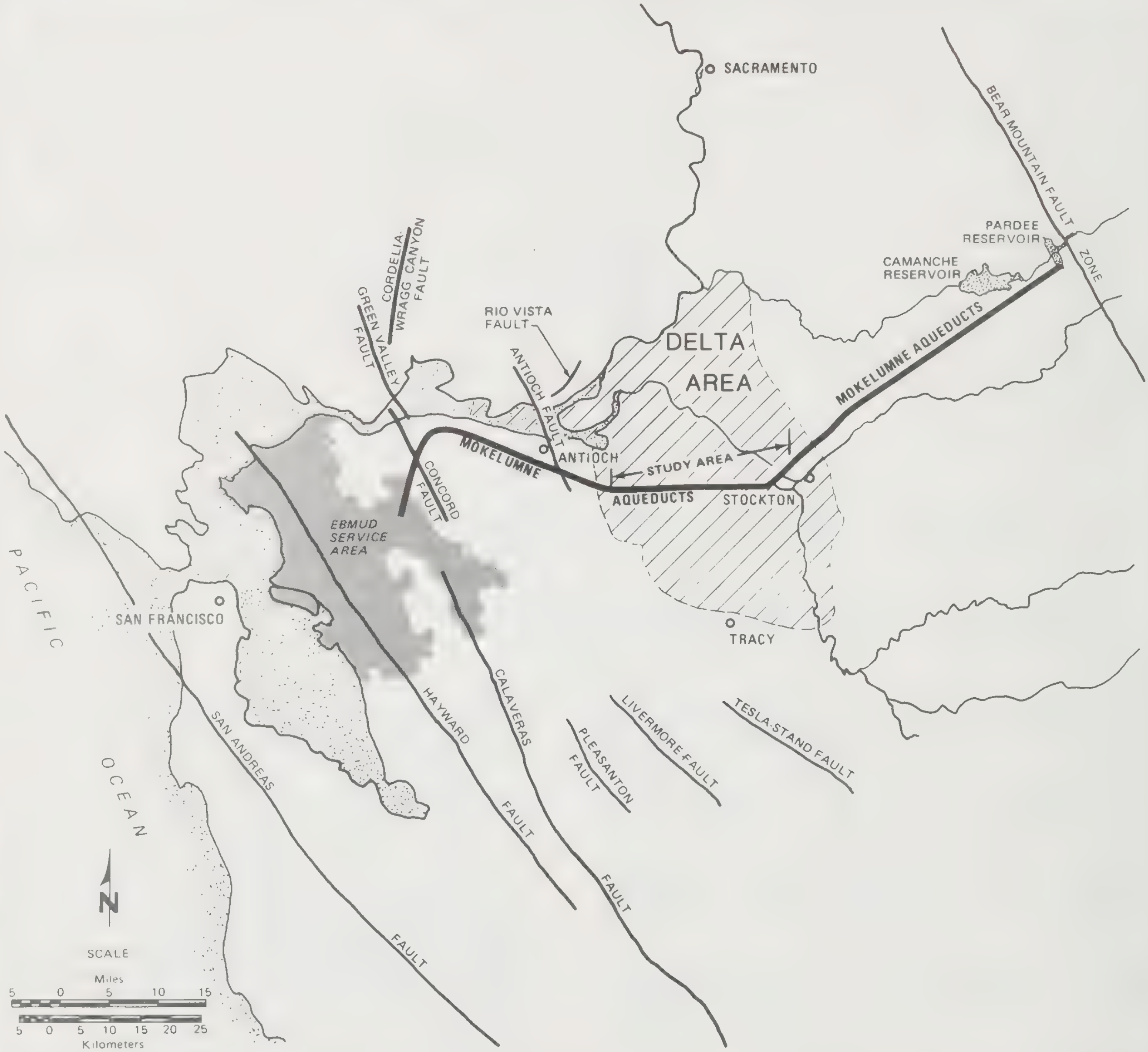
Both the elevated and buried sections of the aqueducts in the Delta are vulnerable to damage from earthquakes and floods. Earthquake damage can be much more severe than flooding. Potential damage from earthquakes, unlike floods, can completely destroy the aqueducts in the Delta. The level of damage from an earthquake depends on the severity of the ground shaking. Potential damage from flooding is related to scour-induced failure and submergence-induced failure. The expected level of damage from earthquakes and floods is summarized in Figure II-12 and discussed more fully below.

**Possible Damage due to Low Ground Shaking.** Elevated sections of Aqueduct No. 1 are seismically weak due to the poor connection between the pipeline and its support. In the event of low level ground shaking (0.05g to 0.10g), Aqueduct No. 1 is considered likely to fail in many locations; however, Aqueducts Nos. 2 and 3 would remain unharmed and a Mokelumne water supply outage would not occur.

**Possible Damage due to Moderate Ground Shaking.** In the event of moderate level ground shaking (0.10g to 0.20g), the expected damage to the Mokelumne Aqueducts increases considerably. The elevated portion of Aqueduct No. 1 is expected to be extensively damaged, while the elevated portions of Aqueducts Nos. 2 and 3 may be broken at several locations. Levee breaks and island flooding are expected, with possible scour damage caused by the flooding. A few breaks in the buried sections of the aqueducts are expected, both on islands and at underwater river crossings. Moderate ground shaking is expected to have a recurrence interval of once every 23 years resulting in a complete outage of the Mokelumne supply. The estimate for the duration of such an outage is a maximum of 10 months to restore full supply.

# Active Faults Near the Delta

Figure II-14

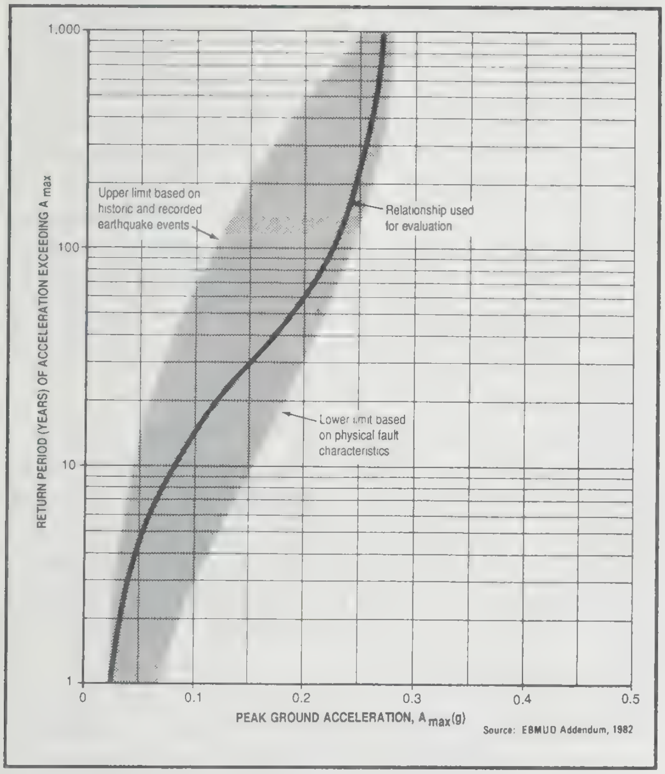



| FAULT NAME | MINIMUM DISTANCE TO STUDY AREA (miles) | MAXIMUM CREDIBLE MAGNITUDE EARTHQUAKE (RICHTER SCALE) | PEAK GROUND ACCELERATION IN THE DELTA (g) |
|---|---|---|---|
| Antioch | 11 | 6-1/2 | 0.27 |
| Rio Vista | 16 | 6 | 0.16 |
| Tesla-Stand | 17 | 6-1/2 | 0.19 |
| Livermore Valley | 22 | 6-1/4 | 0.13 |
| Concord | 22 | 6-1/4 | 0.13 |
| Pleasanton | 23 | 6 | 0.10 |
| Calaveras | 24 | 7 | 0.18 |
| Green Valley | 25 | 6-1/2 | 0.11 |
| Hayward | 34 | 7 | 0.13 |
| Cordelia-Wragg Canyon | 35 | 6-1/2 | 0.09 |
| San Andreas (Northern) | 52 | 8+ | 0.13 |
| Bear Mountain | 44 | 6-1/2 | 0.07 |

Source: Converse, 1981

## Frequency of Maximum Earthquakes

Figure II-15




**Possible Damage due to High Ground Shaking.** In the event of high level ground shaking (0.20g to 0.25g), the expected damage to the Mokelumne Aqueducts is extensive. This level of ground shaking can be caused by the Antioch Fault. The elevated portions of the Aqueduct No. 1 may be completely destroyed, while the elevated portions of Aqueducts Nos. 2 and 3 may be broken at many locations. Levee breaks and island flooding with possible scour damage is expected at several locations. Several breaks in the buried sections of the aqueducts are expected both on the islands and at one or more underwater river crossings. High ground shaking is expected to have a recurrence interval of once every 83 years resulting in a complete outage of the Mokelumne water supply. The estimate for the duration of such an outage is a maximum of 13 months to restore full supply.

**Possible Damage due to Very High Ground Shaking.** In the event of very high level ground shaking (over 0.25g), the expected damage to the Mokelumne Aqueducts is massive. This level of ground shaking can also be caused by the Antioch Fault. The elevated portions of all aqueducts are expected to be destroyed. Many levee breaks and all islands are expected to be flooded, with additional scour damage at many locations. Many breaks in the buried sections of the aqueducts are expected on both the islands and all of the underwater river crossings.

**Scour-Induced Failure.** Levee failures in the Delta have shown that scour erosion can extend to depths exceeding 50 feet, which is deep enough to undermine the pile-supported pipeline sections. Any levee failure occurring near aqueduct channel crossings and along the north end of Woodward Island has a high probability of producing scour-induced aqueduct failure. The expected recurrence of a scour-induced aqueduct failure is once every 27 years (Converse, 1981) assuming present levee conditions. A scour-induced aqueduct failure is expected to result in a complete outage of the Mokelumne Aqueducts for up to 4 months.

**Submergence-Induced Failures.** Levee failure on any of the islands crossed by the aqueducts could result in submergence of the aqueducts. This submergence could result in aqueduct damage only if one is empty. When empty, the aqueducts have enough buoyancy to float free from their supports and fail. Aqueduct No. 1 is particularly vulnerable to submergence-induced damage, since it is not securely fastened to its supports. If the submerged aqueducts were never emptied, they might operate for some time without failure. However, the submergence would prevent easy access, repairs and normal maintenance of damaged aqueduct sections, and would require increased corrosion protection.

### IMPACTS ON DELTA WATER QUALITY

At most times there is sufficient freshwater into the Delta to prevent saline water from entering the western end of the Delta. Inflow from natural runoff is occasionally increased by releases from upstream reservoirs, such as the federally-operated Lake Shasta (whose releases have a 4-day travel time to the Delta) or the state-operated Oroville Reservoir (whose releases have a 3-day travel time). The fresh water inflow rates, physical characteristics of the Delta channels, Pacific Ocean tidal stages and water exports affect the water quality in Delta. Delta water quality is degraded by salt water intrusion from the Pacific Ocean and Suisun Bay, agricultural drainage within the Delta, organic material in Delta soils, and poor water quality from some of the rivers. The water quality in the Delta improves when Sacramento River inflow is high or the exports are low.

The islands and tracts in the Delta are protected from flooding by levees, which require rehabilitation due to subsidence and erosion. The occurrences of levee failures and subsequent flooding are increasing and subjecting the Mokelumne water supply to greater risk of an outage. The following sections will discuss the reasons for the overall subsidence of the Delta, the increased risk of levee failure, and the salinity intrusion affecting water quality.

**Subsidence of Delta Levees.** When most of the levees were built (between 1870 and 1875), the height of the levees above the island floor was 4 to 6 feet; today, to maintain the same elevation against flooding, the height of the levees ranges from 5 to over 25 feet above the island floor. This is because the island floors are continually settling while the levees are built up to prevent overtopping. Figure II-16 illustrates that some Delta islands are subsiding (up to 3 inches per year) due to the loss of peat deposits caused by oxidation, farming, erosion, and burning. The subsidence of the Delta islands has increased the risk of levee failures.

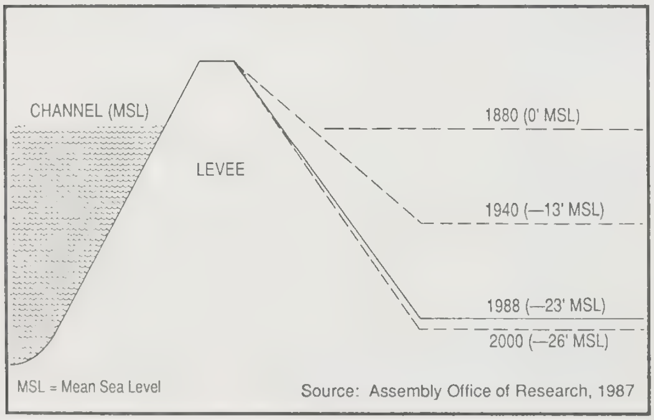
**Reasons for Levee Failures.** Many of the 60 islands and tracts in the Delta have been flooded at least once since their construction. Between 1932 and 1986, there were more than 50 levee failures, as shown in Figure II-17. Figure II-18 shows that between 1950 and 1986 alone there were more than 30 levee failures. Most of the flooded islands have been restored, in certain cases at a cost exceeding the appraised value of the island.

**Salinity Intrusion due to Flooding.** Salinity intrusion is the most serious water quality consequence of Delta flooding. Historically, levee failure and subsequent Delta island flooding have had adverse effects upon water quality and under certain conditions the effects were disastrous. For example, on June 21, 1972, a levee failure (500 feet wide and 75 feet deep) occurred, and Andrus Island and Brannan Island were flooded within three days causing considerable salinity intrusion.

During the emergency, certain Contra Costa Canal users received water with a chloride content as high as 440 milligrams per liter (mg/L). As a result, some industries had to cease operation. However, the chloride content of water delivered to most of the canal users was held to 120 mg/L only by mixing with flows from a temporary connection to the Mokelumne Aqueducts.

## Historical Subsidence of Island Floors

Figure II-16




Source: Assembly Office of Research, 1987

A model (COE, 1984) was developed to determine the effects of island flooding on water quality in the Delta. When island flooding occurs, water quality depends upon the total delta outflow, the tides, the size and location of the island(s), and the amount of water being exported. The model test of a single island flood concluded that levee failure and subsequent flooding of an island at low Delta outflow and high export increases salinity throughout most of the Delta. Another test of 19 islands flooded concluded that salinity increased rapidly until salinity at the intake of the Contra Costa Canal was 2,600 mg/L.

**Effect of Levee Failure on EBMUD.** EBMUD would experience similar salinity levels with Delta water at Indian Slough to those expected at Rock Slough. Figure II-19 correlates flooding and water quality modeled in the COE's study of the Delta. During low to moderate ground shaking, one to three islands crossed by the Mokelumne Aqueducts are expected to flood, resulting in a 10 month outage. The salinity level at Rock Slough peaked at 1,000 mg/L in the model study when one island flooded. The salinity in the model increased to 2,600 mg/L when 19 islands flooded; this could occur during high ground shaking resulting in flooding more than 3 islands used by the Mokelumne Aqueducts. EBMUD may not be able to use Delta water during an outage in the Delta; the water quality may not be acceptable, due to the possible salinity intrusion. Chapter IV discusses, in further detail, the impacts of levee failure on water quality in the Delta.

High Delta outflows at the time of Delta island flooding or levee failure would reduce the impact that would otherwise occur on Delta salinity at the time of the flooding event. However, high Delta outflow is an intermittent event. EBMUD cannot plan on natural disasters occurring only during periods of high Delta outflow.

### Impact of System Failure on the Customer

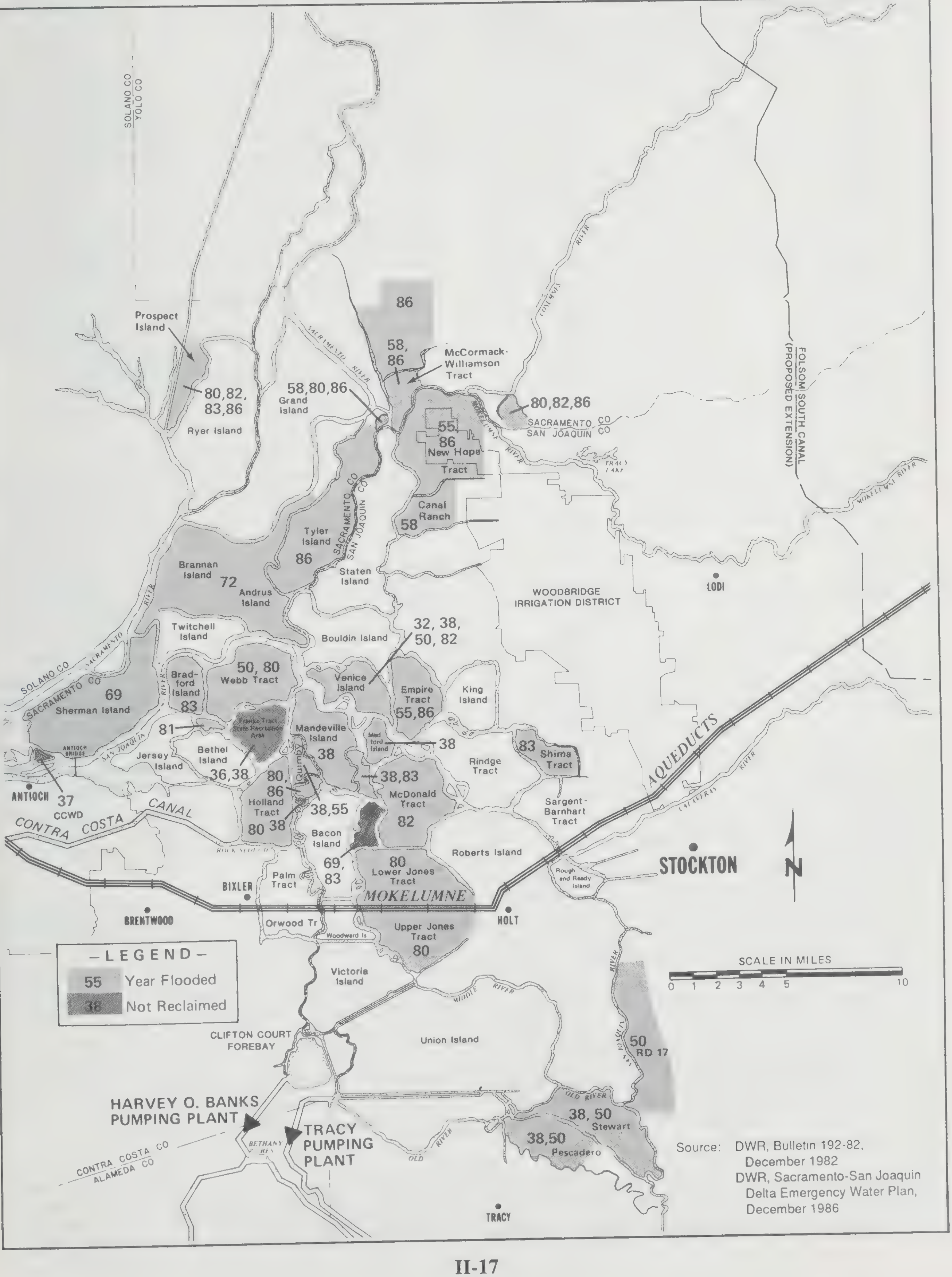
Damage of the Mokelumne water supply system due to earthquake and flood may severely impact the District's customers with water rationing and economic losses over an extended period of time.

HARDSHIP TO THE CUSTOMER

The Mokelumne Aqueducts in the Delta are susceptible to an outage of up to 17 months during a very high level ground shaking event, as discussed previously. Customers could experience water rationing as high as 78 percent during the 17-month

## Delta Areas Flooded by Levee Failure or Overtopping 1932-86

Figure II-17



## Delta Levee Failures, 1950 Through 1986

Figure II-18

| ISLAND OR TRACT | DATE OF FAILURE |
|---|---|
| Venice | 1950 |
| Stewart | 1950 |
| Reclamation District 17 | 1950 |
| Pescadero | 1950 |
| Webb | 1950 |
| Quimby | 1955 |
| Empire | 1955 |
| New Hope | 1955 |
| McCormack-Williamson | 1958 |
| Dead Horse | 1958 |
| Canal Ranch | 1958 |
| Sherman | 1969 |
| Mildred | 1969 |
| Andrus-Brannan | 1972 |
| Webb | 1980 |
| Holland | 1980 |
| Dead Horse | 1980 |
| Upper and Lower Jones | 1980 |
| Little Mandeville | 1980 |
| Prospect | 1980 |
| McDonald | 1982 |
| Venice | 1982 |
| Prospect | 1982 |
| Mildred | 1983 |
| Shima | 1983 |
| Bradford | 1983 |
| Prospect | 1983 |
| McCormack-Williamson | 1986 |
| New Hope | 1986 |
| Dead Horse | 1986 |
| Tyler | 1986 |
| Little Mandeville | 1986 |
| Prospect | 1986 |

Source: DWR, 1986

outage. However, lower levels of ground movement are more likely and an outage time of 13 months is used for planning purposes. Even so, during a 13-month outage, customers may experience water rationing up to 69 percent by the year 2020.

**Earthquakes in the Delta.** Severe earthquakes are the most serious hazard to the aqueducts in the Delta. High to very high ground shaking may cause complete destruction of the aqueducts. The resulting outage of the Mokelumne water supply will include 69 percent rationing during a 13-month outage, unless additional water supplies are provided.

**Indirect Impacts on Customers.** EBMUD customers will incur economic losses due to water rationing caused by extended outages of the District's water supply. In a 1981 Residential Water Use Survey of the effects on customers of the rationing caused by the 1976-1977 drought, it was reported that 54 percent of residential customers interviewed lost a portion of their landscaping. The average cost to replace lost landscaping was $507 per account. Assuming that, during the drought, 54 percent of the District's 263,000 household accounts lost $507, the total cost of replacing residential landscaping was $75 million in 1977 dollars ($115 million in 1988 dollars).

A number of intangible costs associated with rationing exist. These costs include a lack of water for normal housekeeping purposes such as laundering clothes, washing the car, rinsing the driveways and walkways, and increased water hardness/corrosiveness due to lower water quality. In the 1976-1977 drought, there were also economic losses to water-related businesses such as landscapers, car-washers, and laundries.

## ALTERNATIVES

An earthquake could strike at any time causing extensive damage to the District's water supply system in the Delta. Outages lasting up to 17 months can be expected, although a 13-month outage is more likely. If the security of the water supply system is not improved ("do nothing"), the resulting rationing could be severe. Security improvement alternatives are: Foundation improvements in the Delta to reduce the risk of levee failure and aqueduct damage; a new secure aqueduct pipeline in the Delta to replace the existing aqueduct; water banking (additional terminal storage) to provide water supply during a water supply outage; interties with other agencies to access additional water supplies; Delta water use; additional water conservation and reclamation; and possible groundwater resources. The various alternatives to reduce the security risks are discussed in the following sections and shown in Figure II-20.

### Do Nothing

Do nothing would mean a continuation of the present levels of water conservation and reclamation, possible use of Delta water without new facilities and the current level of levee maintenance. In the event of a disaster, EBMUD would not be prepared to minimize the adverse impact on EBMUD customers. Deterioration of the conditions in the Delta, particularly the levees, would over time mean increased vulnerability to damage and collapse of the pipelines with a worsening of the potential impact on EBMUD customers.

The possibility of adverse health risks must be acknowledged when considering the use of Delta water. In 1972, the flooding of Andrus and Brannan

## Flooding Correlation with Salinity

Figure II-19

| CONDITIONS | ISLANDS FLOODED[1] | RECURRENCE INTERVAL, YEARS[2] | AQUEDUCT OUTAGE, MONTHS | PEAK SALINITY AT ROCK SLOUGH[3] |
|---|---|---|---|---|
| **EARTHQUAKES** | | | | |
| Low / Moderate Ground Shaking | Up to 3 | 1 in 23 | Up to 10 | 1,000[4] |
| High Ground Shaking | Greater than 3 | 1 in 83 | Up to 13 | 2,600[5] |
| **FLOODING** | | | | |
| Flooding to +8 MSL with Scour Damage | Up to 3 | 1 in 32 | Up to 4 | 1,000[4] |
| Flooding to >+8 MSL with Scour Damage | Greater than 3 | 1 in 192 | Up to 4 | 2,600[5] |

NOTES:
[1]Islands used by Mokelumne Aqueducts.
[2]Addendum, 1982
[3]Corps of Engineers Model Study, 1982.
[4]Corps of Engineers study modeled on McDonald Island flood.
[5]Corps of Engineers study modeled on 19 islands flooded including Orwood, Woodward and Jones.

## Alternatives to Reduce Security Risk

Figure II-20

| ALTERNATIVE | REMARKS |
|---|---|
| 1. DO NOTHING | Continue present levels of water conservation and reclamation, current levels of maintenance in the Delta, and no new projects. |
| 2. WATER CONSERVATION (Additional Measures) | Continue to implement existing program which would save about 4.0 MGD by year 2020; additional feasible measures would save about 6 MGD by 2020. |
| 3. WATER RECLAMATION (Additional Projects) | Complete the Chevron refinery cooling water project in Richmond and develop and construct Alameda golf course irrigation project (reduce demand by 5.2 MGD); develop and construct irrigation project in San Ramon Valley for golf courses and greenbelt (reduce demand by 1.4 MGD). |
| 4. LEVEE IMPROVEMENTS IN THE DELTA | Complete current levee repair and upgrading work and develop and implement a program of further levee improvements. This alternative would increase security against levee failures, but would not provide protection against ground shaking. |
| 5. NEW AQUEDUCT PIPELINE ACROSS THE DELTA | Construct a single or double 86-inch pipeline across the Delta designed to survive flooding and ground shaking due to an earthquake. Would provide 170–325 MGD capacity, depending on the availability of water at a cost between $175 to $265 million. |
| 6. WATER BANKING (Additional Terminal Storage) | Construct terminal reservoir at either Pinole, Buckhorn or Los Vaqueros sites to provide 50,000 to 155,000 acre-feet, at a cost between $65 million to $186 million. Filling cost would range between $4 million to $17 million. |
| 7. INTERTIES WITH OTHER AGENCIES | Utilize existing interties or construct new interties with other water agencies. Raw water interties with San Francisco (Hetch Hetchy) and the State Water Project (South Bay Aqueduct). Treated water interties with San Francisco (Hayward), CCWD and Zone 7. |
| 8. DELTA WATER USE | Requires additional treatment facilities plus reverse osmosis treatment to use Delta water at a cost of $325–545 million. |
| 9. OTHER SOURCES | Exchange up to 39,000 acre-feet of additional Mokelumne water with Delta with Woodbridge Irrigation Districts if available; purchase Mokelumne water from Woodbridge District or develop conjunctive use projects. |

Islands increased salinity levels in the Delta. Contra Costa Water District (CCWD), a large user of Delta water, purchased EBMUD water because of unacceptable levels of chlorides in the Delta water. Also, CCWD is currently investigating storage of higher quality water in their proposed Los Vaqueros Reservoir, for use when the Delta water quality is extremely low.

The earthquakes producing damage to the aqueducts in the Delta may also increase the salinity of Delta waters. The ground motion created by the earthquake may produce multiple levee failures which will cause island flooding. As previously discussed, the COE model of levee failures and water quality shows that the flooding of 19 Delta islands could result in a salinity of 2,600 mg/L at Rock Slough. Salinities greater than 500 mg/L are not recommended for public consumption over an extended period (California Health and Safety Code, Title 22).

The "do nothing" alternative will continue with the current level of levee maintenance. Thus, the continuing deterioration of the Delta levee system will increase the aqueduct's vulnerability to flooding. As mentioned earlier, in the event of an extended outage, severe rationing of the water supply will be required.

EBMUD customers will experience severe hardships in the "do nothing" alternative as described previously.

### Water Conservation

EBMUD's water conservation efforts began in the early 1970's and have continued with an increased emphasis in recent years. Rationing in 1977 provided first hand experience with customer reaction to a short-term water shortage emergency and the impacts of water use restrictions. It is reasonable to assume that an acceptable level of short-term water conservation through rationing would be required in the event of a disaster, and should be part of EBMUD's water supply planning.

The alternative of expanding EBMUD's water conservation program to keep water demand during normal conditions at a low enough level to survive an extended outage of the Mokelumne supply would have to be based on extreme measures. Demand is currently about 220 MGD and is projected to increase to 280 MGD in 2020. The existing standby storage in the terminal reservoirs will accommodate a demand of only 81 MGD for 13 months, which requires reductions of 63 percent today and 71 percent in 2020.

Chapter III will show that continued implementation of the existing water conservation program could achieve a reduction of 4 MGD in 2020. Additional measures considered to be the most reasonable, feasible, and publicly acceptable would achieve an additional 3 MGD savings, for a total reduction of 7 MGD. Theoretical measures would have a potential for saving an additional 17 MGD in 2020 by getting into the realm of mandatory measures; however, these measures are unproven and could be costly to customers. For example, mandatory replacement of toilets with ultra-low flush models by all residential customers could save about 13 MGD by 2020, but would cost several hundred dollars per household.

A permanent reduction of current demand to 81 MGD (63 percent reduction) would require extraordinary changes in water use by residential, industrial, commercial, institutional, and irrigation customers with significant investment by customers in water saving equipment. There would be major impacts on the economy and lifestyle of the East Bay area. The experience with rationing during 1977 demonstrated what EBMUD customers had to do to achieve only a 39 percent reduction in demand. Landscape irrigation was drastically reduced or eliminated, people flushed toilets and used showers less frequently, and non-essential water uses were suspended. Industrial and institutional customers became more efficient in their water use by installing new equipment, repairing leaks, and modifying processes, much of which continues today making further reductions in water use more difficult.

If the permanent reduction under normal conditions was less, for example a 35 percent reduction to a level of 143 MGD, the restrictions on water use would be similar to the rationing in 1977 but with long-term adverse impacts on the economy and lifestyle. Then in the event of an extended outage, extreme measures would be necessary to further reduce demand by 63 percent.

It is difficult to determine the reductions that would be assigned to the various categories of customers. However, if the impact on the economy of the region were to be minimized then most of the burden for the 63 percent reduction would have to be borne by an even greater reduction in residential and irrigation water uses (together they account for about two-thirds of current demand).

As new development receives water service and demand increases, the extreme water conservation measures would have to become stricter to be able to survive a 13-month outage. The 63 percent would increase to a 71 percent reduction in 2020 to achieve a demand level of 81 MGD.

EBMUD's effort in 1987 to have customers voluntarily reduce demand by 12 percent during the

last half of the year did not achieve that result, although it may have been responsible for the demand not increasing. Obviously, the intended results of a water conservation program are not reliable and cannot be predicted. Public acceptance is an important factor.

Water pricing has been investigated as a water conservation measure, but EBMUD experience and studies show that under normal water supply conditions it is not effective. For example, the 50 percent increase in water rates for water service to customers at higher elevations over the past five years has shown no reduction in water use. Furthermore, EBMUD is required by law to charge no more than the actual cost of providing water service. On the other hand, the 1977 experience with rationing showed that the threat of severe financial penalties for excessive use coupled with the declaration of an emergency can be effective on a short-term basis.

Water use efficiency through conservation is an important element of water supply management; however, it is not a viable alternative for security of the EBMUD water supply against extended outages because the demand reduction needed (63 to 71 percent) would require extraordinary changes in water use by EBMUD customers that would be expensive and would adversely impact the economy and lifestyle of the East Bay area.

### Water Reclamation

The reuse of water through water reclamation is an option for non-potable water uses such as irrigation and industrial cooling. Feasible reclamation projects require a large non-potable demand near a wastewater source with limited treatment requirements. Chapter III will show that current reclamation projects save approximately 4.7 MGD, and additional projects could reduce demand by an additional 5 MGD. Future reclamation projects could provide some additional savings, but not in the range of the 139 to 189 MGD reduction necessary to be able to survive a 13-month outage of the Mokelumne supply (see water conservation discussion above). Current, water reclamation and conservation would reduce the projected demand in 2020 from 280 MGD to about 270 MGD. Water reclamation cannot alone or in combination with water conservation be a viable alternative for security of the EBMUD water supply against extended outages.

### Levee Improvements in the Delta

EBMUD participates in the maintenance, repair, and upgrading of levees to avoid deterioration of the conditions that could cause levee failure due to sloughing, erosion, or over-topping. From 1981 through 1987, EBMUD contributed $1.3 million to this reclamation work, and its additional contribution for completing it would be about $2.0 million. This would maintain the existing level of risk of failure.

However, it would not provide protection against levee failure caused by an earthquake and the potential for an extended outage of the water supply system. Earthquakes cause levee failures because of the poor foundation conditions (the peat and sandy soils on which the levees were built) and the poor quality of levee construction.

If the levees could be adequately reinforced, the foundation conditions under the levees and aqueduct pipelines adequately improved, and the pipeline supports and piles reconstructed to resist very high levels of groundshaking due to a major earthquake, then the risk of an extended outage of the water supply system would be substantially reduced. However, this is not feasible because such levee reinforcement and foundation improvement technology is only conceptual and unpredictable, and the cost of reconstructing the pipeline supports and piles would exceed that of building a separate new pipeline across the Delta.

Repairs and maintenance of Delta levees since 1981, including minor repairs, upgrading, and raising levees at river crossings, have cost $3.2 million of which EBMUD has contributed over $1 million. An inspection conducted in March 1987 by the District's Aqueduct Section indicated that further levee improvements will be necessary on Woodward Island, Palm Tract, and Lower Jones Tract. The District is planning an additional $2 million (1988 dollars) for completing this work and may spend another $6 million for further levee improvements. The proposed improvements would be eligible for state reimbursement under the Way-Mobley Act described earlier in this chapter and could extend over 3 years.

Substantial levee improvements have been made on Woodward Island. Several locations along the east and south levees will need to have the crest elevations raised. Palm and Orwood Tracts are separated by a railroad embankment similar to Lower and Upper Jones Tracts. Although the Mokelumne Aqueducts do not cross Palm Tract, flooding of Palm Tract would endanger the aqueducts on adjoining Orwood Tract. Required levee improvements on Palm Tract include raising the elevation and widening the levees.

The elevated portion of Mokelumne Aqueduct No. 1 was constructed in 1927. Remedial measures costing an estimated $30 million would allow the support system to survive a low 0.16g acceleration. These modifications would not be effective against outages due to moderate or high levels of ground shaking. Severe rationing of up to 69 percent would still be required during 13-month outage. Aqueduct modifications would not increase the District's ability to meet demands during a drought.

The cost of the investigation and feasibility studies is estimated at $0.5 million and the field testing of possible support systems is estimated at $1.5 million. The cost of preliminary design of a new pipeline **depends on the effort required, which cannot be determined until after the investigation, testing, and studies. While this preliminary engineering for foundation improvements is not an alternative for security, it would be an effective part of EBMUD's water supply management.**

The aqueducts also do not cross Lower Jones Tract; however, flooding of Lower Jones Tract will pass through the trestle section of the embankment that separates Lower and Upper Jones Tracts. Since the flooding of Lower and Upper Jones Tracts in 1980, the District approved a resolution to contribute $50,000 toward levee improvements on Lower Jones Tract. Due to the opening in the railroad embankment, Lower Jones Tract levees are even more vital to the security of the Mokelumne Aqueducts. Recommended levee improvements on Lower Jones Tract consists of raising the elevation and widening the levees.

Levee repairs and maintenance provide protection for the existing aqueducts against levee failure due to sloughing, erosion, or over-topping. However, this work will not provide protection against damage to the existing aqueducts due to low/moderate levels of ground shaking and will not reduce the risk of an extended outage of the Mokelumne water supply. There is preliminary engineering work that should be done before future improvements in the Delta can be made:

- Investigation and feasibility studies of levee reinforcement and of modification of supports under the existing aqueduct pipelines for reducing the risk of aqueduct damage due to flooding and lower levels of groundshaking caused by earthquakes; and
- Field testing and preliminary design of possible pile support systems and future aqueduct pipeline across the Delta to shorten the response time in the event of a disaster.

Investigation and feasibility studies will identify the most cost-effective methods necessary to improve the security of the water supply in the Delta. These studies will include investigations to reinforce the levee crossings and to modify the support of existing aqueducts.

Levee reinforcement would minimize the risk of levee failure at the river crossings and the potential for damage to the aqueducts from scour. The levees would be reinforced for 500 feet on either side of the aqueducts on each levee at the aqueduct river crossings. Locations of levee reinforcement include crossings at San Joaquin River, Trapper Slough, Middle River, Old River, and Indian Slough. Figure II-21 shows the possible location of the levee reinforcement.

Testing would be required before levee reinforcement design work could begin. Reinforcement of the Delta levees has not been attempted and its effectiveness is not known. Studies in the Delta will determine the feasibility and appropriate design for reinforcing the levees. The studies must be completed before levee testing can begin.

In the event of damage to the Mokelumne Aqueducts, it would be necessary to begin repairs or replacements as soon as possible; therefore, it is necessary to begin the design of a secure aqueduct based on the results of the pile testing. The cost of preliminary design of a new pipeline depends on effort required, which cannot be determined until after the investigation, testing and studies.

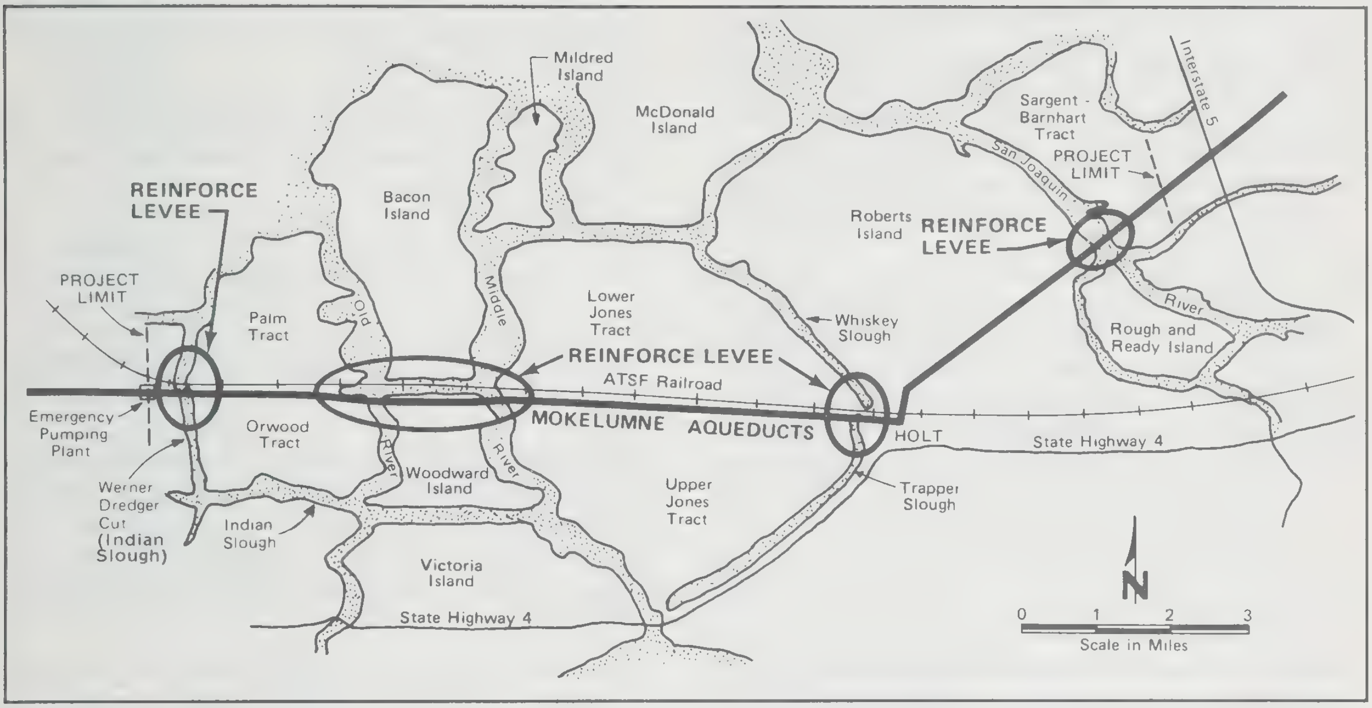
Field testing of pile supports would be required for a future aqueduct replacement. Three areas south of EBMUD's existing right-of-way on Woodward Island and Orwood Tract have been proposed as possible sites for conducting a pile testing program. The piling testing program would be located along a possible future aqueduct alignment up to 500 feet south of the existing pipeline. It has been estimated that pile testing program would take two years to accomplish.

### New Pipeline Across the Delta

Construction of a new pipeline or pipelines across or around the Delta could provide secure delivery of the Mokelumne supply. It would be designed to survive the estimated maximum groundshaking due to earthquake and long-term inundation if an island is flooded. Partial capacity would require one 86-inch pipeline, and full capacity would require two 86-inch pipelines. Preliminary studies indicate that the most cost-effective alignment is parallel to the existing aqueducts. Aqueduct alternatives include: An elevated

## Areas for Levee Reinforcements

Figure II-21




aqueduct; a buried aqueduct; an aqueduct built on a causeway; and an aqueduct around the Delta.

The implementation of EBMUD's contract with the U. S. Bureau of Reclamation for delivery of supplemental water from the Folsom South Canal could affect the size of the pipeline. Because of the high cost of this alternative, the possibility of a delivery capacity above 325 MGD should be considered. This might require delaying design and construction until the legal obstacles related to the USBR contract are cleared. Chapter V, Section "Compatibility with Future Decisions and Needs" discusses the status of the litigation.

The pile supports under the elevated pipe would be designed to withstand the maximum expected earthquake forces and to accommodate the liquefiable sandy foundation soils. The design would also take into account the effects of scour around pipe supports from the flow through a levee break. Field testing of pipe support and pile system designs and investigation of levee reinforcement at river crossings would be needed. The estimated total project cost for one pipeline is $175 million and for the double pipeline is $265 million.

The buried aqueduct would be designed to survive the maximum ground shaking due to earthquakes and would not be affected by the inundation of any of the islands. The estimated construction cost of a double pipeline is $305 million (1988 dollars).

An aqueduct system built on an earthen causeway would be designed to survive the maximum ground shaking due to earthquakes and would be elevated above flood levels. The estimated construction cost of a double pipeline is $535 million (in 1988 dollars) also will require preliminary engineering in the Delta.

Another secure aqueduct alternative would be built around the vulnerable Delta area. The route would extend around the southern end of the Delta, from Bixler to Holt. The estimated construction cost of a double pipeline is $415 million (in 1988 dollars).

### Water Banking (Additional Terminal Storage)

EBMUD has five terminal reservoirs in the East Bay hills which provide a total of about 138,000 acre-feet of usable storage. Terminal reservoirs provide the following five functions:

- Emergency Standby - storage maintained to meet demand during short term disruptions of supply when there is insufficient time to impose mandatory rationing. It provides a minimum of 120 days of supply at normal demand. This is the time needed to repair damages to tunnels, pumping plants, and pipelines. This emergency standby is also maintained during a two year drought period.
- Seasonal Regulation - store Mokelumne River in the winter and spring, when Sierra runoff occurs

and demand is low, for use during the high demand period in the summer months.

- Drought Reserve - for dry periods such as 1976-1977 and other years on hydrologic record.

- Develop Local Yield - collect and store storm runoff from the reservoir watersheds. The storage capacity for regulation and local yield is shown in Figure II-22.

- Environmental Preservation and Recreation - 27,000 acres of watershed land on which these reservoirs are located provide open space and water related recreation. These lands and water constitute a priceless urban refuge permanently protected from development. These watershed lands and the adjacent regional parks include an 80-mile system of trails wandering east of the Oakland-Berkeley Hills.

The total amount of unusable storage, as shown in Figure II-22, in the reservoirs is 17,500 acre-feet. This is storage space that is generally unusable and is dependent on the elevation of the outlet works. The total amount of storage space provided for regulation, also shown in Figure II-22, varies from a minimum of 13,500 acre-feet in April to a maximum of 37,000 acre-feet in November.

At the projected demand of 270 MGD in the year 2020, the additional storage and costs to limit rationing would be:

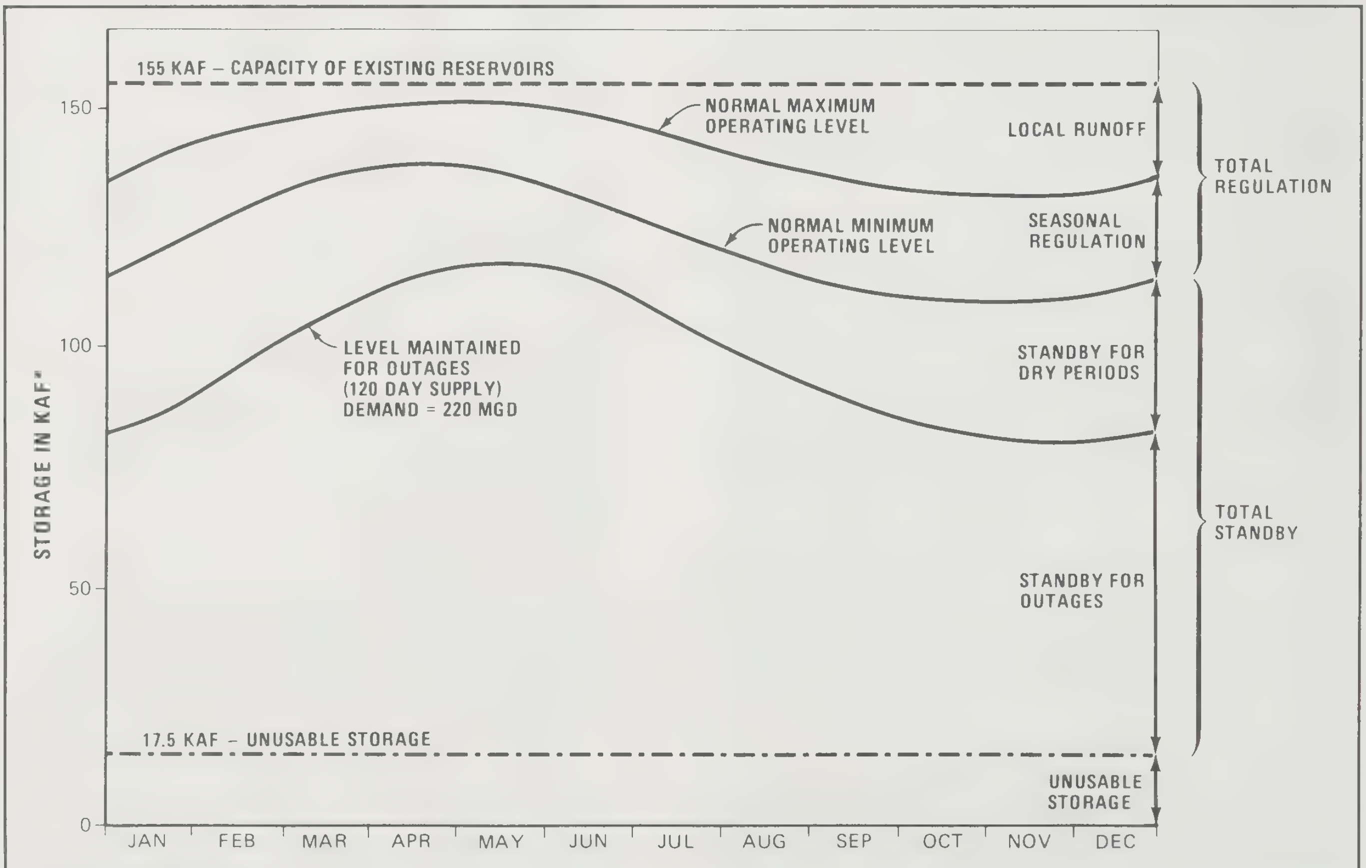
| Limit on Rationing | 13-month Outage | Estimated Range of Costs |
|---|---|---|
| 39 percent (reduction) | 100,000 AF | \$122M-\$150M |
| 25 percent (reduction) | 145,000 AF | \$152M-\$186M |

Additional terminal storage will increase the standby storage and reduce severe rationing during an extended outage. The 39 percent limit is existing policy; the 25 percent limit would be a change in policy to reduce the severity of rationing as will be discussed in Chapter III.

Given the various combination of events, possible damage, and possible outage times, a 13-month outage is a more likely event for planning purposes than a 17-month outage. The maximum 17-month

## Functions of Terminal Reservoirs

Figure II-22




*KAF = 1000 Acre-Feet

outage would require larger additional storage, but poses a much lower risk. Figure II-23 illustrates the amount of storage needed to provide water during an outage at various levels of rationing. By the year 2020, EBMUD's existing terminal storage would result in customer rationing of 69 percent in a 13-month outage without additional terminal storage.

The operational cost of filling a new reservoir would range from $11 to $17 million (1988 costs), depending on the site and the size.

In the event of damage to the Mokelumne Aqueducts, it would be necessary to begin repairs or replacement as soon as possible. This alternative would provide sufficient storage to allow time for the repairs or replacement. In combination with this alternative, it will be necessary to continue the levee repair and maintenance program and begin the study of levee reinforcement and pile testing in preparation for the design of a secure aqueduct.

## Interties with Other Agencies

Adjacent and nearby water supply systems of other agencies offer the possibility of emergency supplies during an extended outage of the Mokelumne system. No utility has a significant long-term surplus that EBMUD can depend on for the required water quantity and outage time. In addition, water rights and environmental issues associated with any change in source or place of use could be significant. Nevertheless, intertie possibilities need to be considered.

San Francisco's Hetch Hetchy system could be connected to EBMUD through the City of Hayward, with which EBMUD has emergency connections, or by constructing a major transmission pipeline from Walnut Creek south to Sunol in the Livermore Valley (27 miles) or from the Brentwood area south to a point in the Central Valley (25 miles) as shown in Figure II-24. The water quality would be similar to that of the Mokelumne River. The existing Hayward connections can deliver only 5 to 10 MGD, whereas a major transmission pipeline could deliver a significant quantity of water. Such a pipeline could cost approximately $100 million. Any interties with the Hetch Hetchy system might help in the event of a Mokelumne supply outage, if the water were available; but this is an uncertainty.

The Contra Costa Water District (CCWD) obtains its water supplies from Rock Slough in the Delta, under a contract with U.S. Bureau of Reclamation, and Mallard Slough, under its own water rights. The system has no appreciable storage, but CCWD is planning the construction of Los Vaqueros Reservoir. A supply from the Delta through CCWD is not a viable source that EBMUD could depend on because the flooding of islands resulting from a disaster in the Delta could cause salt water intrusion from the Bay with extremely high salinity levels. If use of Delta water were feasible, then EBMUD could take delivery of its American River entitlement directly from the Delta as it did in 1977, rather than going through CCWD.

**There is a possibility that a limited quantity, about 15 MGD, of treated water might be available on a seasonal basis from CCWD's Bollman Treatment Plant, but would be uncertain as to long-term availability. The pipeline and pumping plant required to deliver water from the treatment plant to the Mokelumne Aqueducts would cost about $1 million.**

The South Bay Aqueduct of the State Water Project extends through the southerly part of the Livermore Valley. Its capacity appears to be fully contracted for. The source is the Delta, (Clifton Court) which is further southeast than Rock Slough. The impact of salt water intrusion might be less at Clifton Court depending on the type of disaster and the extent of flooding. Apart from the salinity problem, EBMUD's major treatment plants are not equipped to treat Delta water. The intertie would require the construction of a treatment plant which would cost over $370 million (1988 dollars). In addition, an 111-inch diameter pipeline estimated to cost about $40 million would be needed. The general pipeline alignment could extend from Bethany Reservoir (South Bay Aqueduct) to the Mokelumne Aqueducts near Brentwood.

**Another consideration would be use of State Project water from the Santa Clara Valley Water District (SCVWD), which has several sources of supply, by wheeling it through the facilities and treatment plant of the Alameda County Flood Control and Water Conservation District Zone 7 in the Livermore Valley. The limited capacity for treatment in Zone 7 would restrict this option to only 5-10 MGD. A pipeline and pumping plant would be required, but feasibility is uncertain and a specific project has not yet been developed. The cost may be on the order of $10 million.**

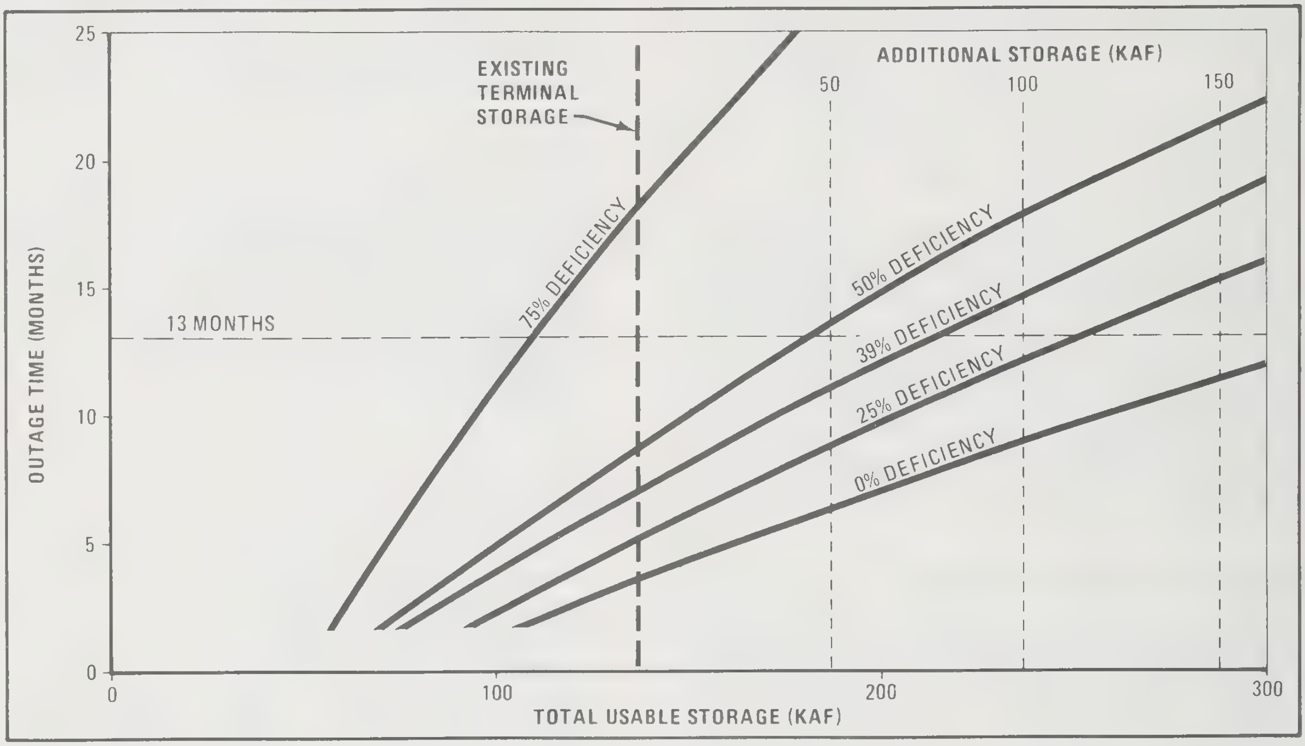
### Delta Water

During an extended outage resulting from flooding in the Delta, the water quality could deteriorate due to salt water intrusion and inflows of agricultural drainage. The District's major water treatment plants are not equipped to treat Delta water. **To be able to plan on using Delta water during an extended outage of the Mokelumne supply would require**

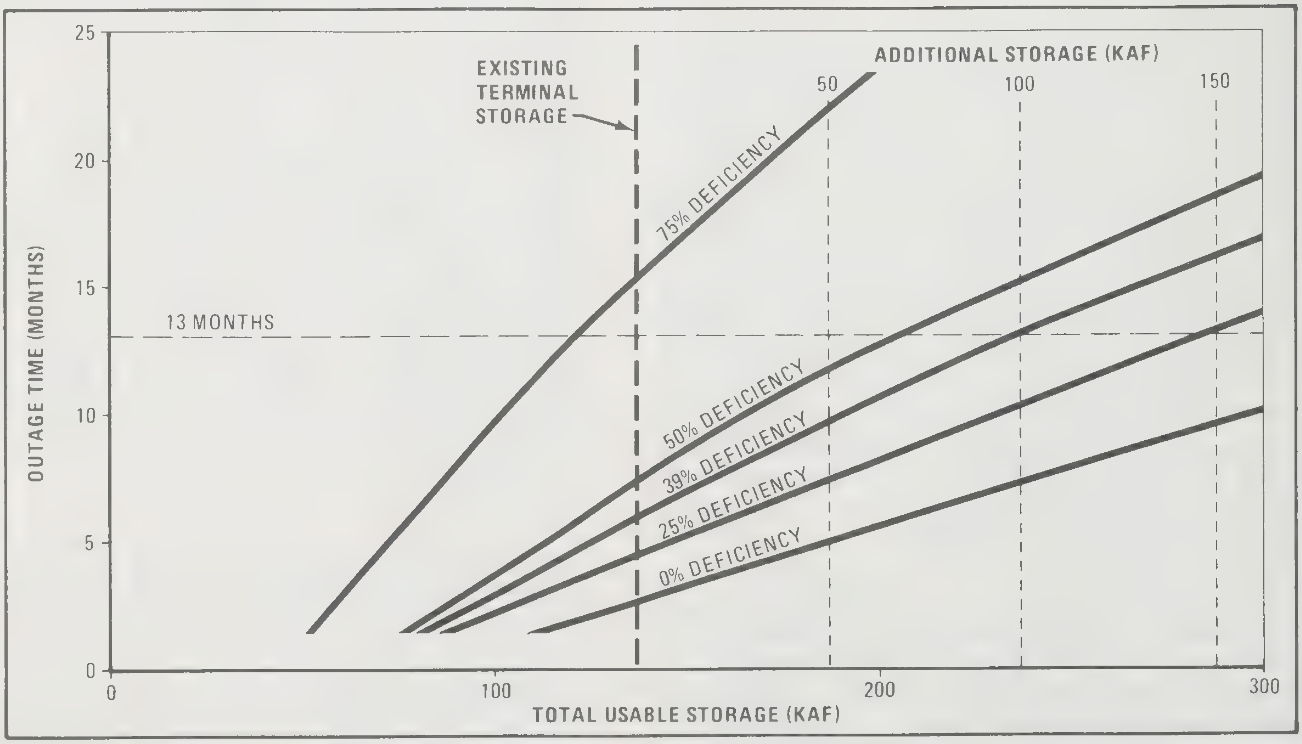
## Storage Requirements at Different Levels of Deficiencies

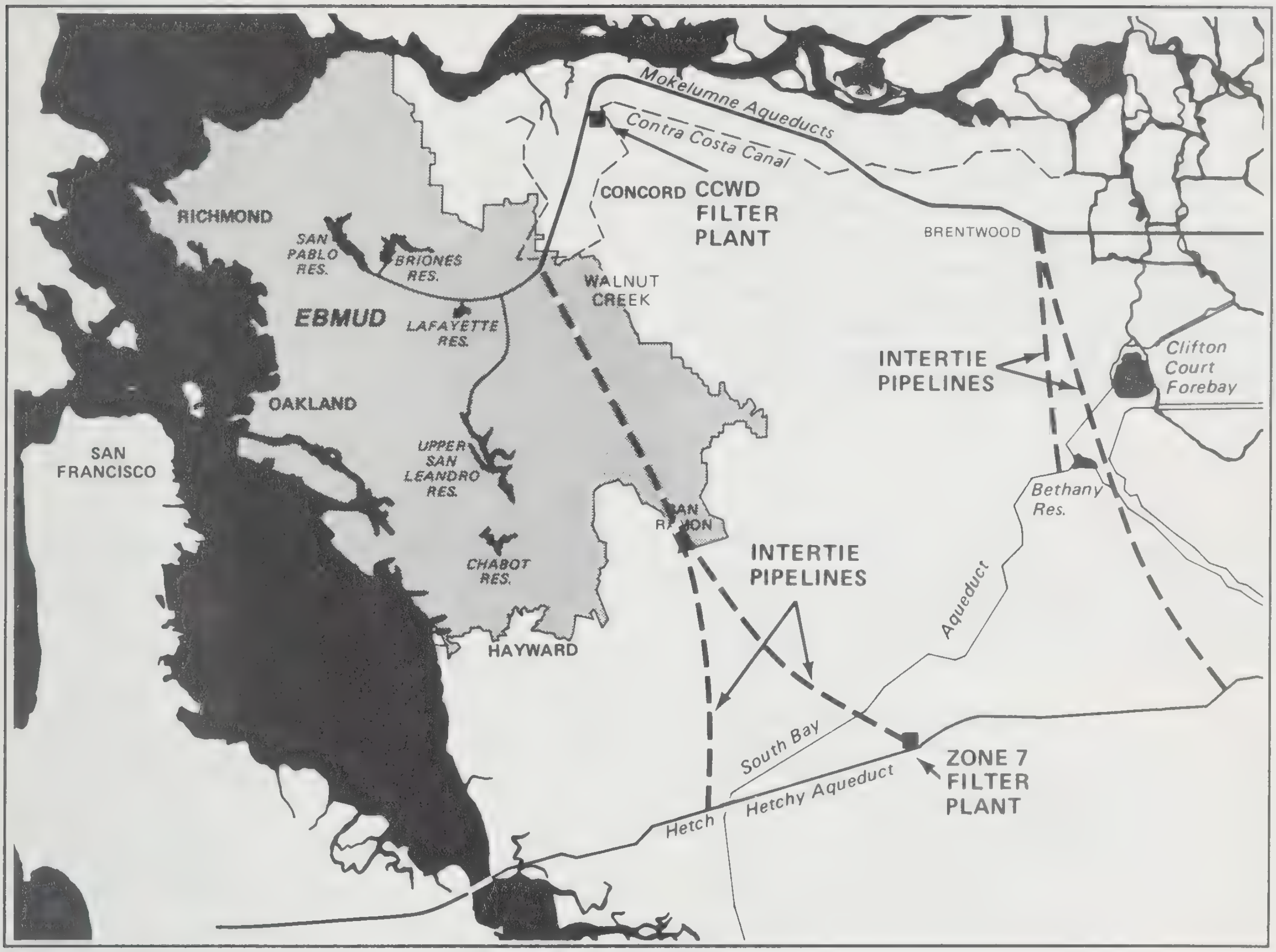
Figure II-23

### 1990 Demands (225 MGD)




### 2020 Demands (270 MGD)






**construction of pretreatment and desalinization facilities at the source. Pretreatment would remove turbidity, disinfect, and reduce the THM formation potential. Such facilities would cost in the range of $200 to $370 million, depending on the additional facilities required at existing filter plants for reduction of the THM formation potential. Desalinization would involve reverse osmosis treatment to reduce the elevated levels of total dissolved solids because of the extremely high salinity expected. Such facilities would be an additional cost in the range of $125 to $175 million, depending on the method of brine disposal. The brine might be pumped by pipeline to San Francisco Bay. The total cost of facilities for use of Delta water would be in the range of $325 to $545 million. This treatment would not necessarily eliminate the long-term health risks related to use of Delta water.** A detailed discussion of the advantages of using Delta water is included in Chapter IV.

EBMUD has maintained a policy of obtaining high quality water and has not diverted water from the Delta, except in 1977. The District's 1983 Citizen Advisory Committee recommended against such diversions, and both federal and state policies urges providing water from the highest source. It would not be desirable to deliver Delta water to EBMUD customers for 13 months, given the District's present treatment capability. The cost and impact to the District's customers would be the same as the "do nothing" alternative.

## Other Sources

### GROUNDWATER RESOURCES

A recent report (Todd, 1986) of groundwater resources in the EBMUD service area identified two potential groundwater basins for municipal development. The potential yield from these two basins together was estimated to be 1 to 2 MGD,

however, they have very poor water quality. Two potential groundwater basins are situated in the San Leandro area (East Bay Plain, South) and San Ramon Valley.

## EXCHANGE WITH WOODBRIDGE DISTRICT

**An exchange of water with the Woodbridge Irrigation District would not provide security against an outage because the supply would experience the same extended outage as the present Mokelumne supply. Details of the agreement and projects considered with the Woodbridge Irrigation District are included in Chapter III, section "Woodbridge Irrigation District (WID) Exchange".**

# Chapter III
# Shortages:
# Meet Dry Year Demands

## EXISTING WATER SUPPLY CONDITIONS

### Problem

Customers are now and will experience greater hardships during dry periods, despite significant reductions in water use. There is a decreasing availability of supply as demands by other users on the Mokelumne River increase.

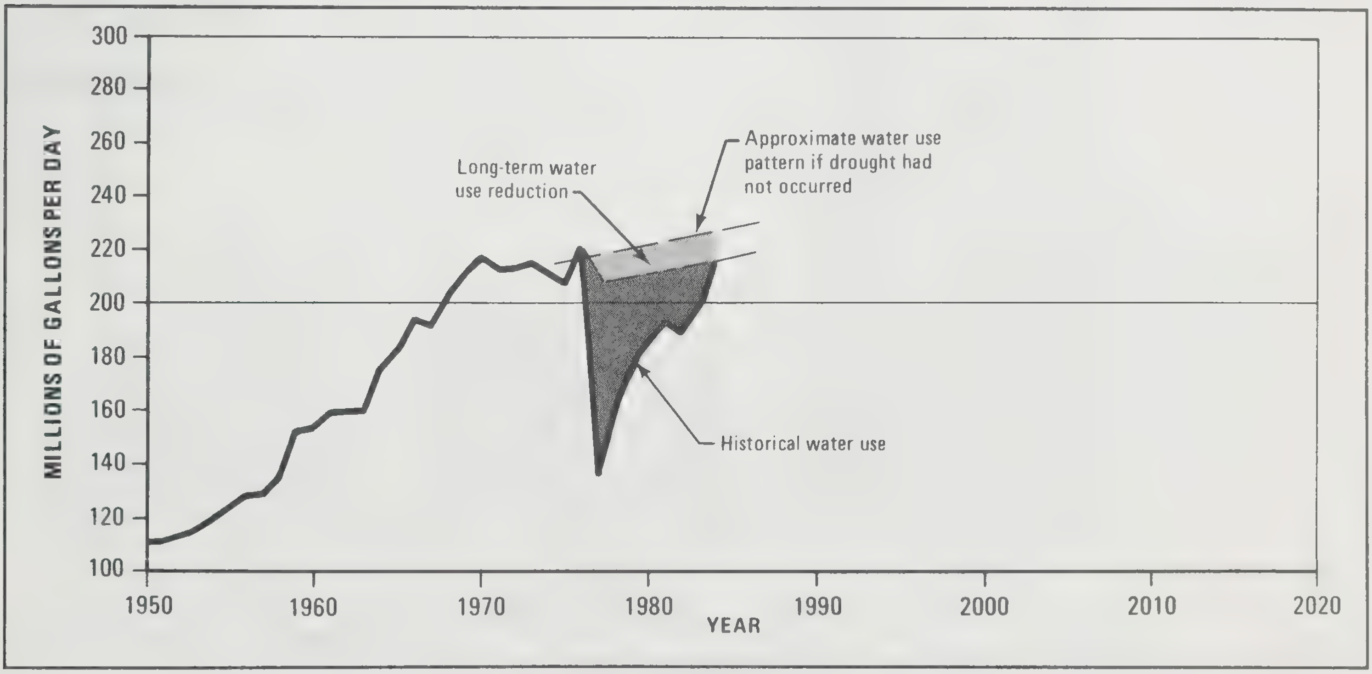
This chapter describes EBMUD's existing water supply conditions and discusses the ability of the existing water supply system to meet present and future demands. This chapter also identifies alternatives to solve the shortage problem described above so that EBMUD customers can continue to receive reasonable quantities of high quality drinking water.

### Existing Water Demand

The 1987 level of demand in the EBMUD service area was 218 MGD, and Figure III-1 illustrates the historic water use within EBMUD. The large reduction in use in the mid-1970's reflects the effects of the 1976-77 drought. The 1975-76 and 1976-77

Historical Water Use and Effects of Water Conservation Implemented During the 1976-77 Drought

Figure III-1



runoff seasons produced the worst continuous dry period ever recorded in the Mokelumne watershed where EBMUD obtains about 95 percent of its water supply.

After the 1976 seasonal runoff, the District requested that customers voluntarily reduce water use by 25 percent. When it became evident in early 1977 that runoff would be even lower, the District imposed a mandatory water conservation program aimed at an overall 25 percent reduction in water use. In May of 1977, after analyzing the results of the final snow survey, the water supply situation became more serious, and the District imposed a 35 percent cutback for the remainder of the 1977 calendar year. Customers responded well to the conservation program, and on the whole came up with a larger reduction in use (about 39 percent) than was expected.

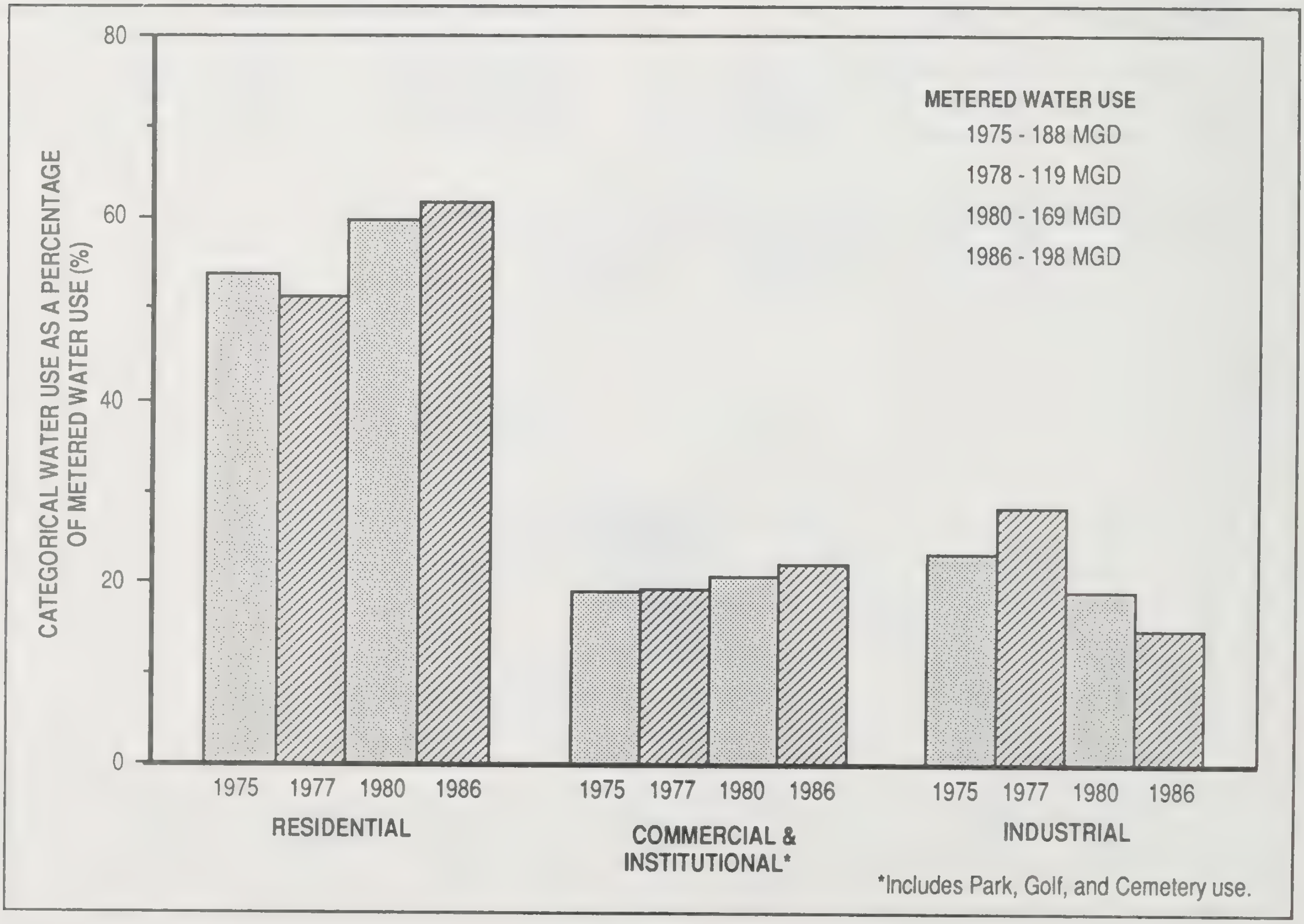
In the years following the drought, water use remained below the pre-drought (1975) level of 208 MGD and has just recently returned to that level, although with an increased number of customers. Figure III-2 shows that, while much of the water conservation efforts in 1977 resulted in short term reductions such as habit changes in residential use, many of the structural changes, such as industries' modifying water-using equipment, resulted in long-term water use reductions.

These long-term reductions are now reflected in the improved efficiency of normal water usage in the service area. The level of demand in 1986 was 215 MGD, only slightly higher than the level of demand in 1975 even though there are now about 35,000 more customers than there were in 1975. Figure III-1 shows conceptually the increased efficiency which can be attributed to the long-term reductions initiated during the drought.

Figure III-3 compares the per capita use of water in the District with water use data from other water utilities. The data show that per capita water use in the District is comparable to water use in other water districts and is often lower, particularly among residential customers.

## Historical Water Use Characteristics

Figure III-2

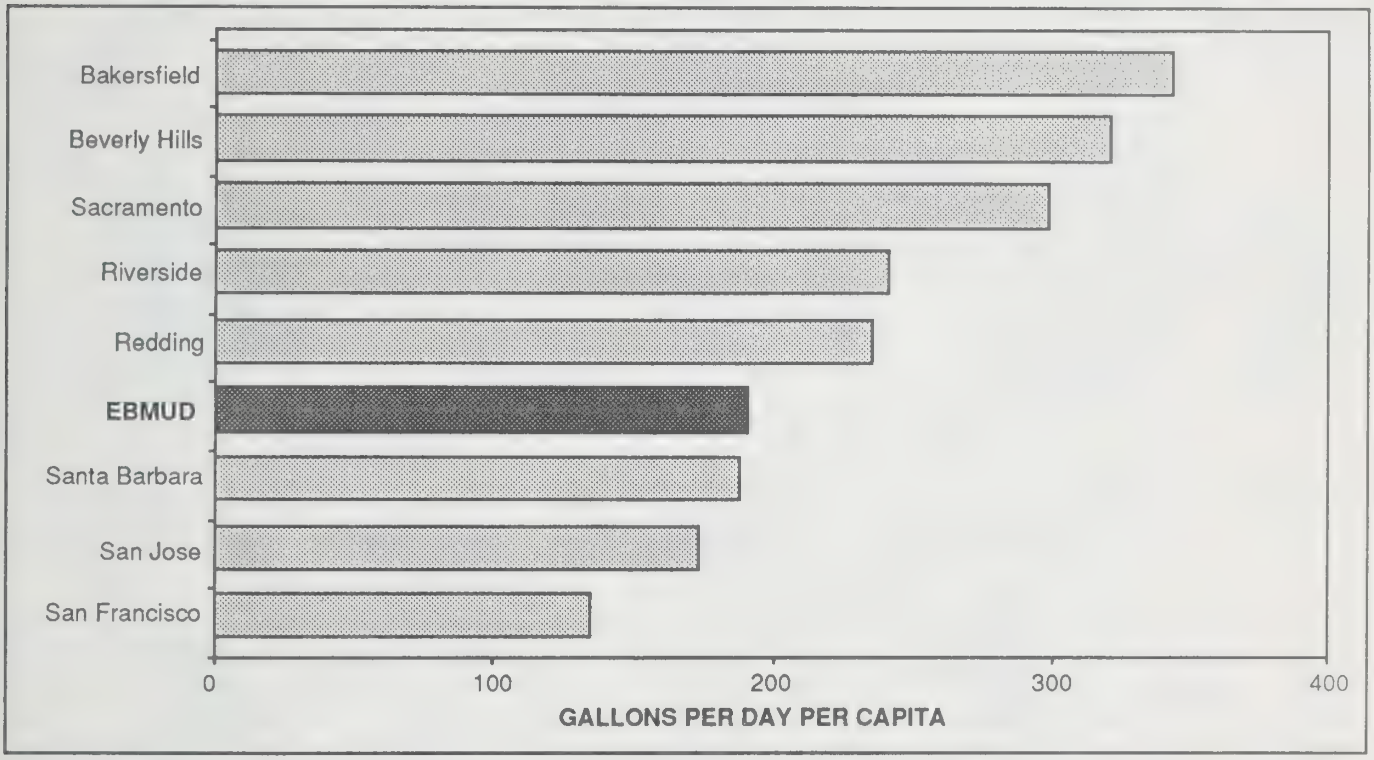


EBMUD has made detailed studies of water use patterns. This information is used for projecting future demands and identifying areas for further water conservation efforts. Figure III-4 shows a breakdown of water use into categories. Single-family water use predominates in the District followed roughly equally by multi-family, industrial, and commercial and institutional. Overall, residential water use is about 62 percent of the total metered consumption. Sixty-seven percent of all water use is inside use.

The EBMUD service area has significant variations in geographic, climatic, and land use characteristics. A review of the water use data shows that the last year of "average" water use occurred in 1981. Years since then have been either wetter or drier than normal with correspondingly lower and higher water use patterns. For this reason, 1981 residential water use data were selected for planning purposes.

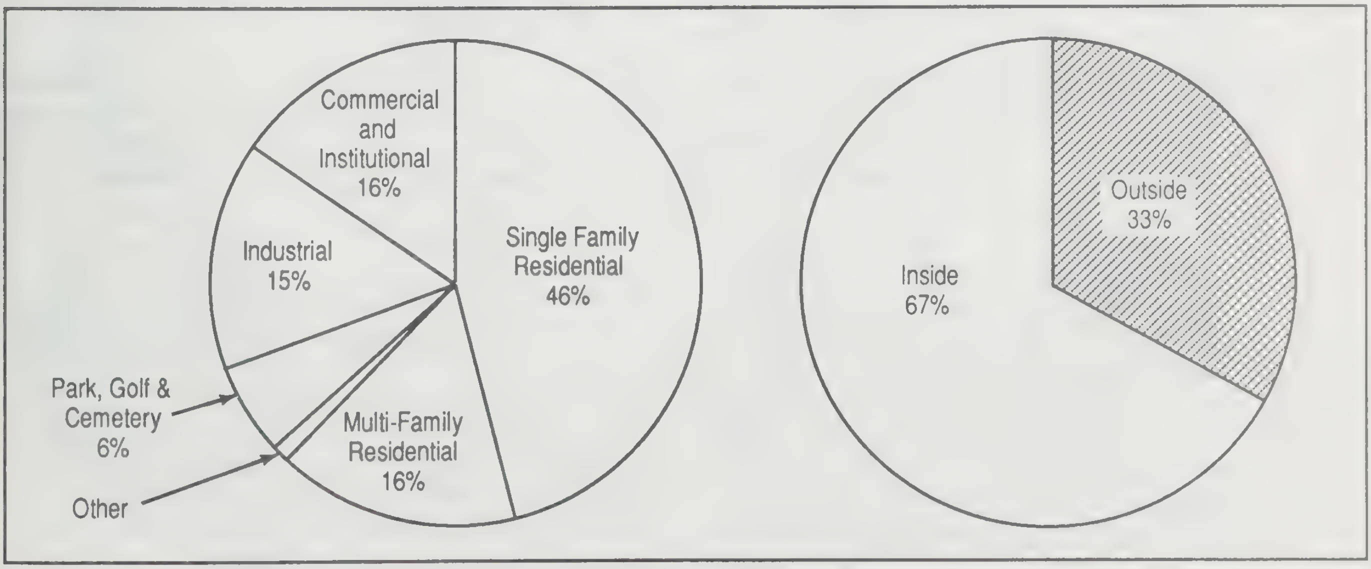
## Per Capita Water Use by Selected Communities

Figure III-3




## EBMUD Water Use Characteristics

Figure III-4

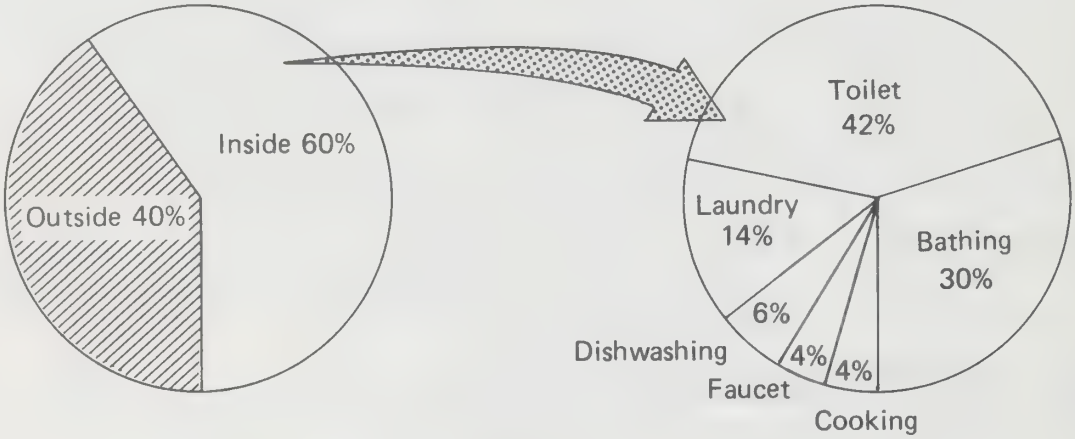


Figures III-5 and III-6 provide a breakdown of the specific types of residential uses. They show that 60 percent of the use (65 gal/capita/day) occurs inside and 40 percent of the use (43 gal/capita/day) occurs outside. Approximately 72 percent of the inside water use is for flushing toilets and for bathing. Approximately 90 percent of the outside water use is for irrigation.

The EBMUD service area has been divided into seven regions for planning distribution system facilities and for charging new customers for costs of constructing new facilities. These seven regions also define areas which have similar water use patterns due to common geographical, climatological, and land use characteristics. Figure III-7 shows inside and outside regional single-family water use in the seven regions.

## Residential Water Use

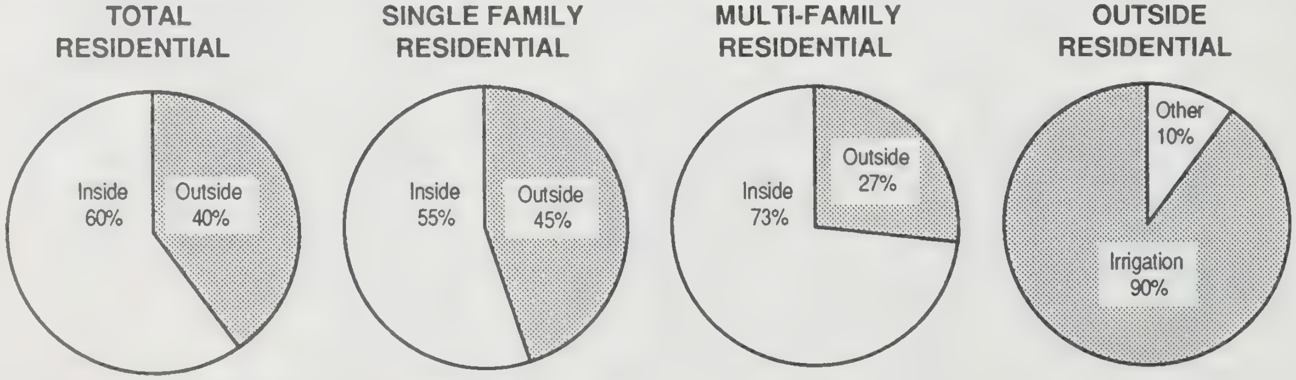
Figure III-5




| Inside Water Use | Percent | Gal/Capita/day |
|---|---|---|
| Toilet | 42 | 27 |
| Bath/Shower | 30 | 19 |
| Laundry | 14 | 9 |
| Dishwashing | 6 | 4 |
| Faucet | 4 | 3 |
| Cooking | 4 | 3 |
| Total | 100% | 65 |

## Inside and Outside Residential Water Use

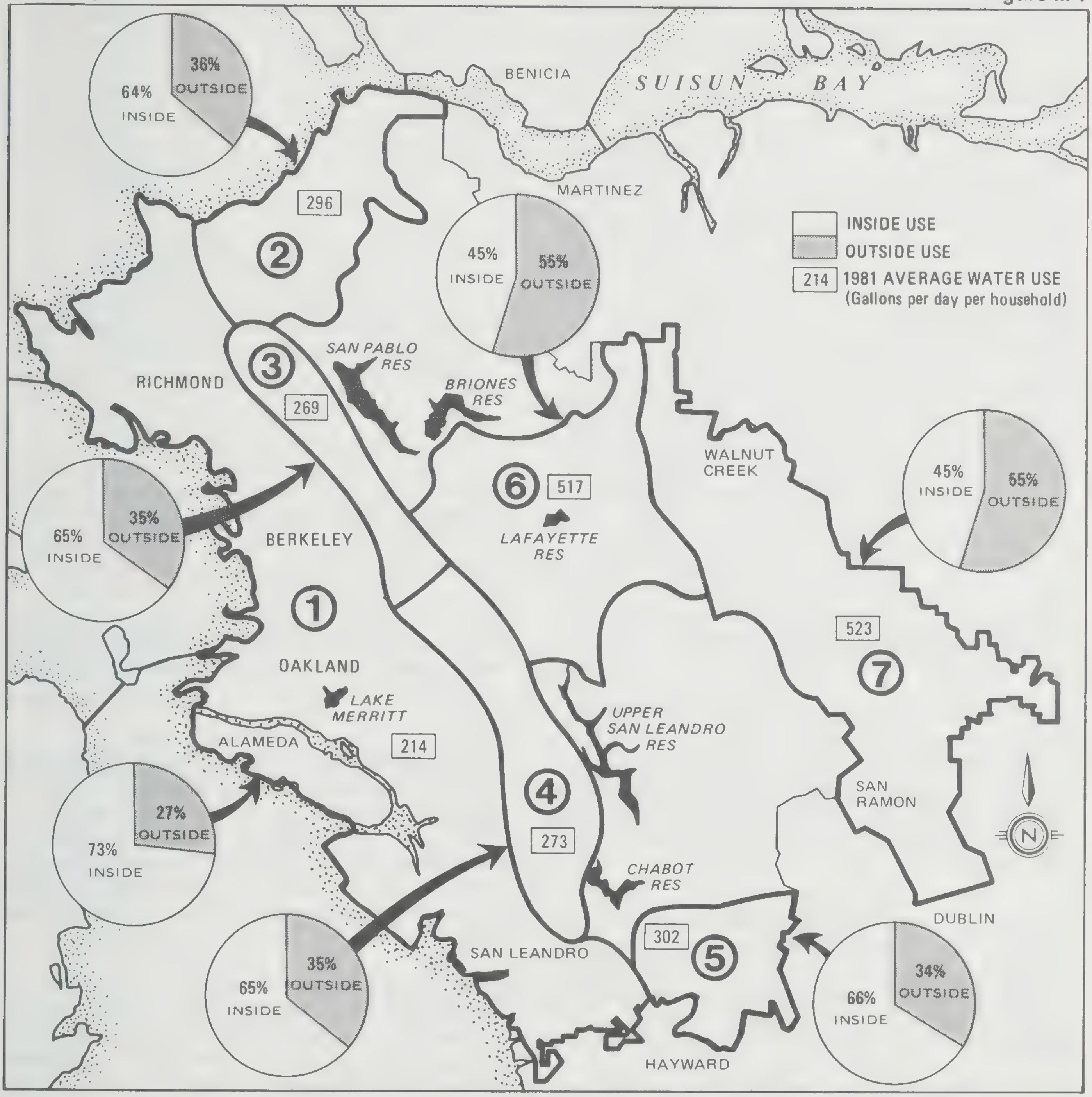
Figure III-6




Source: Urban Water Management Plan, EBMUD 1985

## Single Family Residential Inside and Outside Water Use by Region

Figure III-7

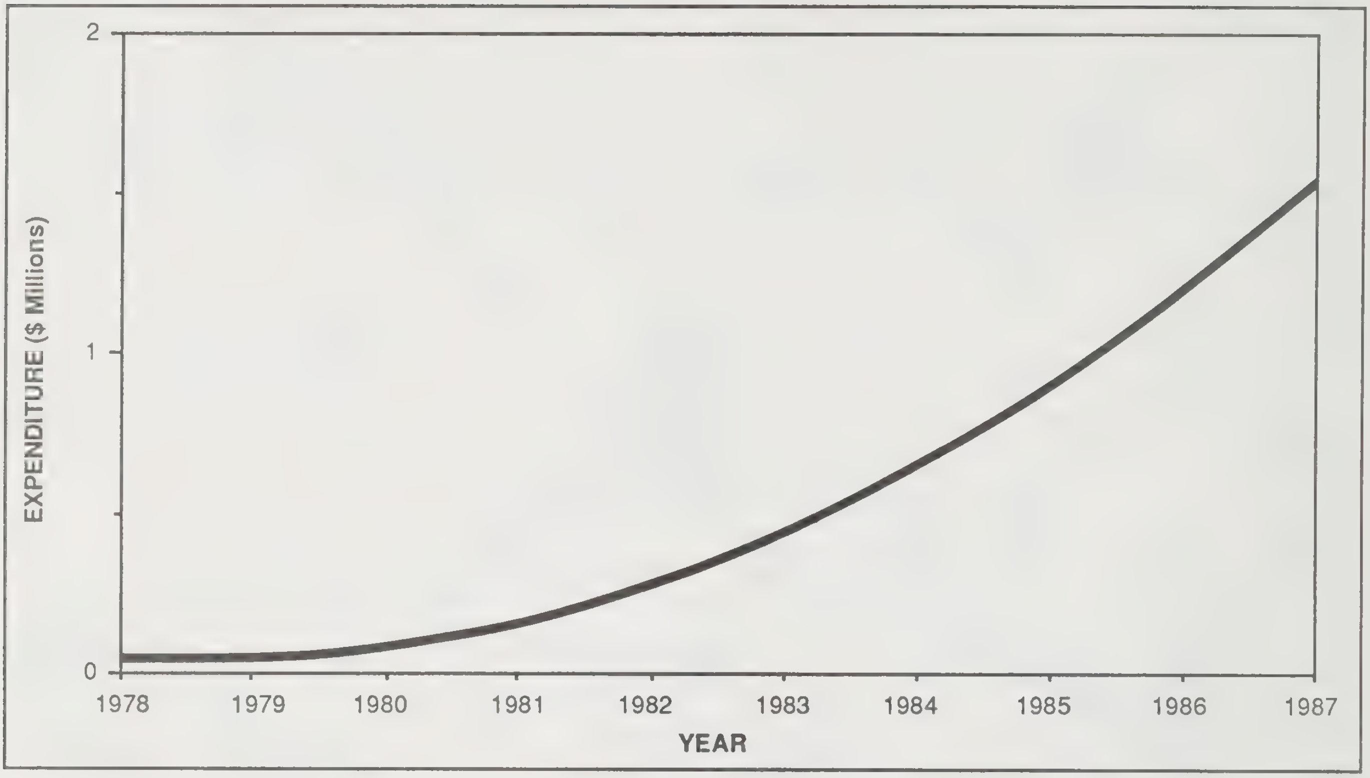



### Water Conservation Activities

Figure III-8 shows the District's water conservation expenditures during the last ten years. Water conservation budgets provide for reasonable long-term and continuous efforts to improve water use efficiency and to ensure the best use of existing supplies. Short-term demand reduction measures are those actions taken in response to water shortage due to drought (1976-77 and 1987-88) or other supply emergencies. The distinction between long-term water conservation and short-term demand reduction is important in evaluating the need for, and impacts of, water conservation measures.

## Water Conservation Expenditures for Past Ten Years

Figure III-8




### HISTORIC WATER CONSERVATION ACTIVITIES

EBMUD has a long history of water conservation efforts. As early as 1923, water meters were required in the East Bay as a means of saving water and collecting revenue equitably. Other long standing conservation measures include public information and school education, leak detection, and pipe replacement.

**Metering.** District regulations require all users to be served through a meter. The requirement is enforced through continuing inspections. Occasionally illegal connections are discovered and they are immediately metered. Water use at all District facilities is also metered.

The primary purpose of meters is to assure that revenues are fairly collected. Another purpose for metering is to assure that water is used efficiently and leaks on customers' premises are discovered quickly. Nation-wide studies comparing metered water use to unmetered water use show an average reduction of 20 percent in the metered sector. In California, unmetered communities, such as Sacramento, use 50 percent more per capita than EBMUD.

In 1986, EBMUD bills began displaying present and past water use to allow customers to track use. The District also has a meter testing program to routinely test, inspect, and repair water meters, particularly meters for large water users.

**Public Information.** Beginning in the 1960's, when EBMUD completed the third aqueduct to the Mokelumne making its total delivery capacity 325 MGD and raising terminal reservoir storage to 155,000 acre-feet, the District began a pioneering effort in water conservation education, including school education programs that are being used nation-wide.

EBMUD's early conservation efforts were aimed at developing a long-term awareness of water and its efficient use. A series of informational materials such as brochures, bill inserts, posters, and educational publications for schools were developed. The increase in water use slowed in the first half of the 1970's, although other factors such as weather, economics, and environmental awareness undoubtedly contributed to the slowdown.

Although attempts have been made to estimate the actual quantity of water saved through various educational programs, it is difficult, if not impossible, to quantify the effectiveness of these programs. Public information and education are essential elements of a balanced conservation program in that they provide

an awareness of water and its efficient use and inform customers of opportunities to save water.

**Leak Detection.** Of the 215 MGD of water used in 1986, about 7.3 percent was unaccounted-for water. Unaccounted-for water is the difference between the gross quantity of water delivered to the distribution system and metered consumption (including the District's own use). The District's unaccounted-for water losses are less than one-half the national average and are decreasing.

The distribution network includes over 3,600 miles of pipe. Several techniques are used to locate leaks including visual inspections, sonic leak detection, and customer reports. EBMUD has two crews equipped with electronic sound detection equipment as part of a $267,000 annual effort.

The leak detection crews survey approximately 300 miles of pipeline per year. The estimated water saved as a result of the leak detection program ranges from 0.5 to 1.5 MGD each year. The water saved is not cumulative from year to year since it is assumed that the leaks would be discovered within a year or two even without the leak detection program. However, early detection and repair help maintain a tight water system by minimizing unaccounted-for losses. The total number of leaks and breaks repaired each year ranges from 600 to 800.

The leak detection crews also generate approximately 500 repair orders per year to repair meters and hydrants. These are not included in the water savings estimate since it is assumed that if there were no leak detection program, the leaks would be reported by meter readers as a result of their routine activities.

Several hundred door hangers are also distributed every year. These are used when leaks or open plumbing are discovered on customers' lines. The notifications are made to encourage customers to correct any problems in their plumbing. The effect of these notices is intangible and not included in the water savings estimates.

**Pipe Replacement.** Many conditions contribute to the deterioration of pipelines in the distribution system, including pipe type and size, soil conditions, and ground movement. Figure III-9 shows pipe type, age, and vulnerability to breaks. Because of the leak detection and pipe replacement programs, the system has a declining leakage factor. The District currently invests about $3.6 million per year towards the replacement and rehabilitation of water mains.

Records are maintained on the location and type of leaks and breaks. When a section of pipe shows a history of leaks, an analysis is performed on the benefits and costs of replacing the pipe before repairs are made. The District's goal is to replace about 7.5 miles of pipe annually. Currently, the District exceeds its goal.

## Distribution System Pipe Profile

Figure III-9

| PIPE TYPE | MILES INSTALLED IN SYSTEM | MEDIAN AGE (Years) | VULNERABILITY TO BREAKS* (Leaks per 100 miles) | APPROXIMATE NUMBER OF MILES REPLACED EACH YEAR |
|---|---|---|---|---|
| CAST IRON | | | | |
| 2 inch | 27 | 45 | | |
| 4 inch | 322 | 50 | | |
| 6 inch | 758 | 46 | | |
| 8 inch | 208 | 47 | | |
| 12 inch | 76 | 40 | | |
| 16 inch | 25 | 42 | | |
| TOTAL | 1416 | | 34.5 | 5.5 |
| ASBESTOS CEMENT | | | | |
| 4 inch | 21 | 30 | | |
| 6 inch | 663 | 22 | | |
| 8 inch | 322 | 21 | | |
| TOTAL | 1006 | | 11.2 | 1.2 |
| STEEL | | | | |
| 6 inch | 152 | 21 | | |
| 8 inch | 152 | 19 | | |
| 12 inch | 227 | 19 | | |
| 16 inch | 114 | 21 | | |
| TOTAL | 645 | | 4.8 | 1.2 |

*Factors affecting vulnerability to leaks and breaks include: pipe diameter, length, age, lining, coating, year of pipe manufacture and number of breaks in past five years.

A twenty-seven year history of pipe replacement is shown in Figure III-10. During the 1960's, a major effort was undertaken to catch up with pipe replacements. This effort has stabilized at about 7 to 9 miles per year.

**Corrosion Control.** The distribution system is protected by 145 impressed-current cathodic protection stations and over 5,300 magnesium anodes installed on cast iron and steel mains. This program has resulted in a significant reduction in the leak of cast iron and steel pipe and saved about a half million dollars per year in leak repair costs since 1977. Internal corrosion and deposition are also controlled. Lime is added into the water system to raise the pH levels to minimize internal corrosion. Designs are carefully checked to select proper coatings, materials, and paints for all structures to prevent corrosion.

## Pipe Replacement

Figure III-10

| YEAR | MILES | YEAR | MILES |
|---|---|---|---|
| 1961 | 40.18 | 1975 | 6.14 |
| 1962 | 25.45 | 1976 | 7.15 |
| 1963 | 27.39 | 1977 | 5.51 |
| 1964 | 27.65 | 1978 | 2.85 |
| 1965 | 17.65 | 1979 | 2.41 |
| 1966 | 23.21 | 1980 | 5.43 |
| 1967 | 24.68 | 1981 | 8.70 |
| 1968 | 25.11 | 1982 | 9.19 |
| 1969 | 15.24 | 1983 | 8.06 |
| 1970 | 13.61 | 1984 | 6.17 |
| 1971 | 10.20 | 1985 | 8.23 |
| 1972 | 10.66 | 1986 | 7.50 |
| 1973 | 6.34 | 1987 | 8.80 |
| 1974 | 8.46 | | |

## SHORT-TERM WATER USE RESTRICTION IN A DROUGHT

**1976-77 Drought.** The 1976 to 1977 rainfall period was the lowest of record in the service area and in the Mokelumne watershed, where EBMUD obtains 95 percent of its water supply. In June 1976, EBMUD asked customers to voluntarily cutback on water use. Worsening drought conditions in 1977 made mandatory water rationing the primary component of EBMUD's response to dwindling water supplies. In February 1977, mandatory cutbacks averaging 25 percent were imposed, but in May, each customer's allocation was decreased to a 35 percent cutback level. Figure III-11 summarizes how the cutbacks were imposed on the various customer categories. The District's priorities were to reduce water use by as much as practical and to minimize impact on businesses and employment.

Customers responded well to the mandatory program and, as a whole, reduced water use by 39 percent in 1977. Industrial and institutional customers reduced water use by installing new equipment and devices, repairing leaks, and modifying existing processes to achieve their water use goals. Many of the structural changes made by industry resulted in permanent water savings. Currently, water use by industrial customers amounts to 30.1 MGD, only 68 percent of pre-drought levels. In a future drought, these customers will be unable to reduce their demand to the extent that they did previously without causing a serious impact on their operations.

Residential and commercial customers, which account for over 75 percent of metered water use, installed water saving devices in toilets and showers, recovered

## Rationing Imposed During 1976-77 Drought

Figure III-11

| | CATEGORY OF USE | 25% OVERALL REDUCTION FOR 1977 Imposed Feb. 8, 1977 | 35% OVERALL REDUCTION FOR 1977 Imposed May 1, 1977 |
|---|---|---|---|
| ALLOCATION | Single Family Residential — Family of three | 280 gpd* | 225 gpd |
| | Each additional person | 60 gpd | 35 gpd |
| | Multiple Family Residential | 30% | 35% |
| REDUCTION FROM PREVIOUS YEAR | Commercial | 25% | 30% |
| | Institutional | 25% | 30% |
| | Industrial | 10% | 20% |
| | Non-Residential Irrigation | 50% | 60% |

*Gpd is gallons per day.

bath water for garden use, or drastically reduced or eliminated landscape irrigation. Ceasing landscape irrigation caused substantial loss of lawns, shrubs, trees, and property value to many customers. The cost of replacing landscapes lost during the drought has been estimated to be approximately $75 million. Residential and commercial customers saved water mainly through reduced irrigation. However, as landscapes were replaced and water saving habits faded, water use increased. By 1980, water use for residential and commercial customers had reached pre-drought levels.

Between 1975 and 1985, population increased by about 52,000 people or 5 percent. During that same period of time, the number of residential accounts increased by 8.7 percent, and the number of non-residential accounts increased by 13.9 percent. Since 1975, per account water use for non-residential customers has decreased by 15 percent, while per capita residential water use has increased by 11 percent.

**1987-88 Drought.** Following a critically dry winter of 1986-87 in the Mokelumne watershed, the District embarked on a voluntary demand reduction program in an attempt to get customers to reduce their water use by 12 percent over the previous year's level. This effort was necessary to minimize the risk and magnitude of water supply deficiency in 1988 should that year prove to also be dry.

The short-term measures implemented in 1987 are shown in Figure III-12. The cost of this effort was $550,000. Customer response to dry conditions was less than the 12 percent reduction requested. It is estimated that water use was only 5 percent less than it would normally have been considering weather conditions during the summer of 1987. The reason for this, it is believed, is that customers did not perceive a serious drought condition to exist. However, the drought persisted into 1988, water supplies remained low, and mandatory water rationing was imposed in June 1988.

## 1987-88 Demand Reduction Program

Figure III-12

| MAY THROUGH DECEMBER 1987 | 1988 |
|---|---|
| **CONSERVATION WORKSHOPS**<br>District conducted eleven workshops for public agencies and large irrigators to provide information on landscape irrigation requirements and scheduling. | **WATER RATIONING**<br>Impose mandatory water rationing on all customers effective June 1, 1988 with objective of 25% savings; enforce rationing with inclining block rate structure |
| **WATER USE REDUCTION REQUEST LETTERS**<br>Postcards requesting water conservation were sent to all customers in May 1987. Letters requesting conservation were sent to 7,000 large irrigators. | **SUSPENSION OF SURPLUS WATER SALES**<br>All surplus water sales have been suspended until after the drought and surplus water supplies become available. |
| **LAWN WATERING CONSERVATION GUIDES**<br>Guides describing the amount and timing of lawn watering were sent to 282,000 customers. | **PROHIBITION OF ANNEXATIONS**<br>No new annexations beyond the ultimate boundary, which may become a permanent moratorium. |
| **CONSERVATION EDUCATION IN PUBLIC SCHOOLS**<br>Water conservation information including bumper stickers, diamond signs, magnets and other material were distributed to students in June and September of 1987. | **WATER SAVING DEVICE DISTRIBUTION**<br>Approximately 50,000 kits including showerheads and toilet displacement bags have been distributed; moisture sensors and hose nozzles are being distributed. |
| **RADIO ADS AIRED DISTRICT WIDE**<br>A total of 666 radio spots were aired on ten radio stations through September 1987. | **WATER AUDITS AND CONSULTATIONS**<br>The District has conducted over 400 water audits of customer water use; the District is also working with public agencies and large industrial and irrigation customers to curtail use. |
| **CONSERVATION PLACARDS ON PUBLIC TRANSPORTATION**<br>Water conservation placards were placed on 210 AC Transit buses and 30 placards were placed at BART stations. | **WATER USE PROHIBITIONS**<br>Prohibit planting of turf for new homes, water use for fountains, limit washing of cars and sidewalks, restrict irrigation to odd/even days, and limit construction water use. No irrigation of landscaping if the city or county has not adopted EBMUD's landscape guidelines. |
| **WASTE WATCHERS**<br>Twelve summer employees patrolled the service area looking for water waste. Waste watchers would alert customers of waste and provide conservation information. Four employees were retained for the winter. | **PUBLIC INFORMATION CAMPAIGN**<br>Includes newspaper ads, radio spots, public displays, bill inserts, awards program, and reprint of landscaping book.<br><br>**WASTE WATCHERS**<br>Waste watcher patrol has been increased to 18 employees to patrol service area and provide water conservation information. |

The 1987-88 runoff conditions proved to be as dry as 1986-87, and water storage levels have continued to decline. Following public hearings held in March 1988, the EBMUD Board of Directors determined that a water shortage emergency existed and adopted emergency water use reduction measures which were expected to reduce overall water consumption by 25 percent.

The 1988 demand reduction program is summarized in Figure III-12. The total cost of the measures was estimated to be $1.8 million. Water use during the summer of 1988 has been reduced by approximately 30 percent as a result of the District's and customer's efforts.

## LONG-TERM WATER CONSERVATION

**Demonstration Gardens.** A landscape water conservation demonstration garden pilot project was started in 1981 to retrofit three residential front yard gardens. It demonstrated the attractiveness and benefits of low water use and low maintenance drought-tolerant landscaping in Berkeley, Lafayette, and Moraga. The front yards were landscaped by three different landscape architects to show a variety of ways to work with drought tolerant plants.

The garden installations were completed in October 1983. Even though 1984 was hotter and drier than normal, causing demand to rise approximately 10 percent District-wide, water use for the demonstration gardens dropped nearly 45 percent from the previous four-year average. Once fully established, the demonstration gardens have shown that outside water use can be reduced by up to 90 percent by replacing lawns with low water landscapes. These gardens were developed and tended under controlled conditions, but the potential for water savings is significant although some objections to their appearance were noted.

The gardens have been publicized since the spring of 1985 through newspaper articles and other media channels. The homeowners keep weekly logs of the time they spend on weeding and other maintenance and monitor water use. EBMUD plans to continue to monitor and evaluate the demonstration gardens for several years.

In addition, a Resource Garden, installed at Lake Merritt in Oakland in 1982, is part of a cooperative effort between EBMUD, the City of Oakland, the State of California, and the U. S. Environmental Protection Agency. The garden is a demonstration site showing the use of composted sewage sludge, low water using plants, and efficient irrigation systems.

Additional demonstration gardens built with the cooperation of other public agencies include: landscaping at the District's Alamo business office, a traffic median in the City of Danville, and a 20,000 square feet garden at Heather Farms park in Walnut Creek. Figure III-13 shows the water savings achieved at the Alamo demonstration garden site. Currently, the District is working with the City of Alameda and the City of Oakland to establish additional demonstration garden projects.

The District typically contributes $5000 to $10,000 to each garden and provides technical and design assistance. New gardens are constructed at the rate of about two per year.

**Water Pricing.** Water pricing is frequently suggested as a way to reduce excess water use. If water pricing influences water use in the United States generally, or in EBMUD specifically, it has not been demonstrated by any current statistical techniques. The reason for this is that the total cost of water to the average residential user is very small.

In 1983, the District adopted an elevation surcharge that increased the costs to water users at higher elevations by 30 to 50 percent in two different areas. To date, there has been no statistically demonstrable difference in water use in these areas. (See Figure III-14.) However, if significant increases are also applied at the same time during rationing when there is a general public awareness of shortage, there may be a combined effect.

In the drought of 1976-77, it was difficult to determine whether the public perception of the drought or the dramatic rate increase (100 percent excess use charge for use over the allotment) was more effective in reducing demand. Clearly the combined effect was significant. Therefore, pricing has been considered a demand reduction measure as part of a short-term drought management program.

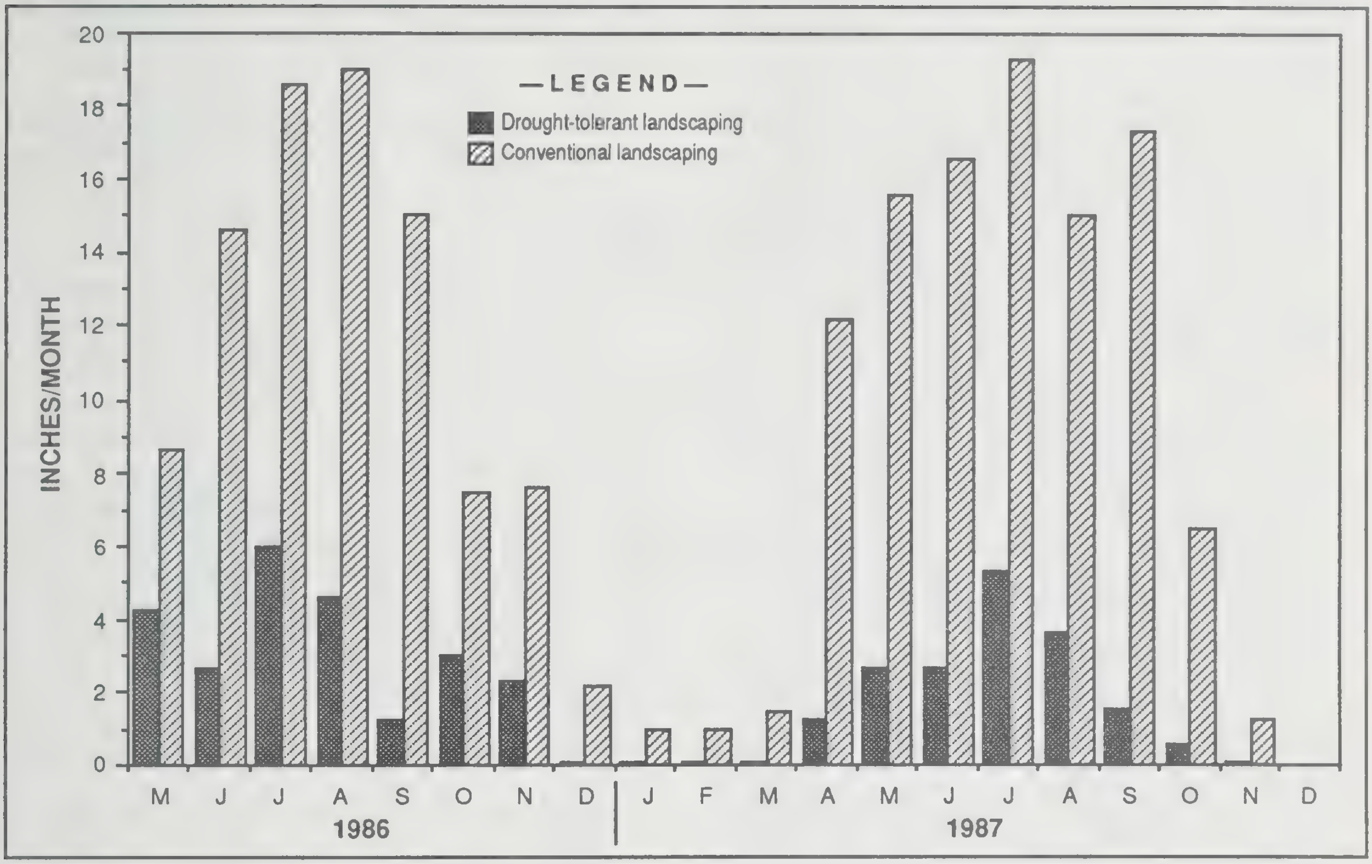
## URBAN WATER MANAGEMENT PLAN

In 1985, in response to the Urban Water Management Planning Act (AB 797), which was sponsored by EBMUD, the District prepared its first Urban Water Management Plan. That plan identified a series of water conservation measures, which are shown in Figure III-15. The following is a discussion of the current status of implementation of the plan's activities.

**Water Saving Device Distribution.** In 1986, the District distributed 5,000 retrofit kits, which included a 2.75 gpm low-flow showerhead and toilet dams to save 0.5 gal/flush, to hotels, motels, apartments, and

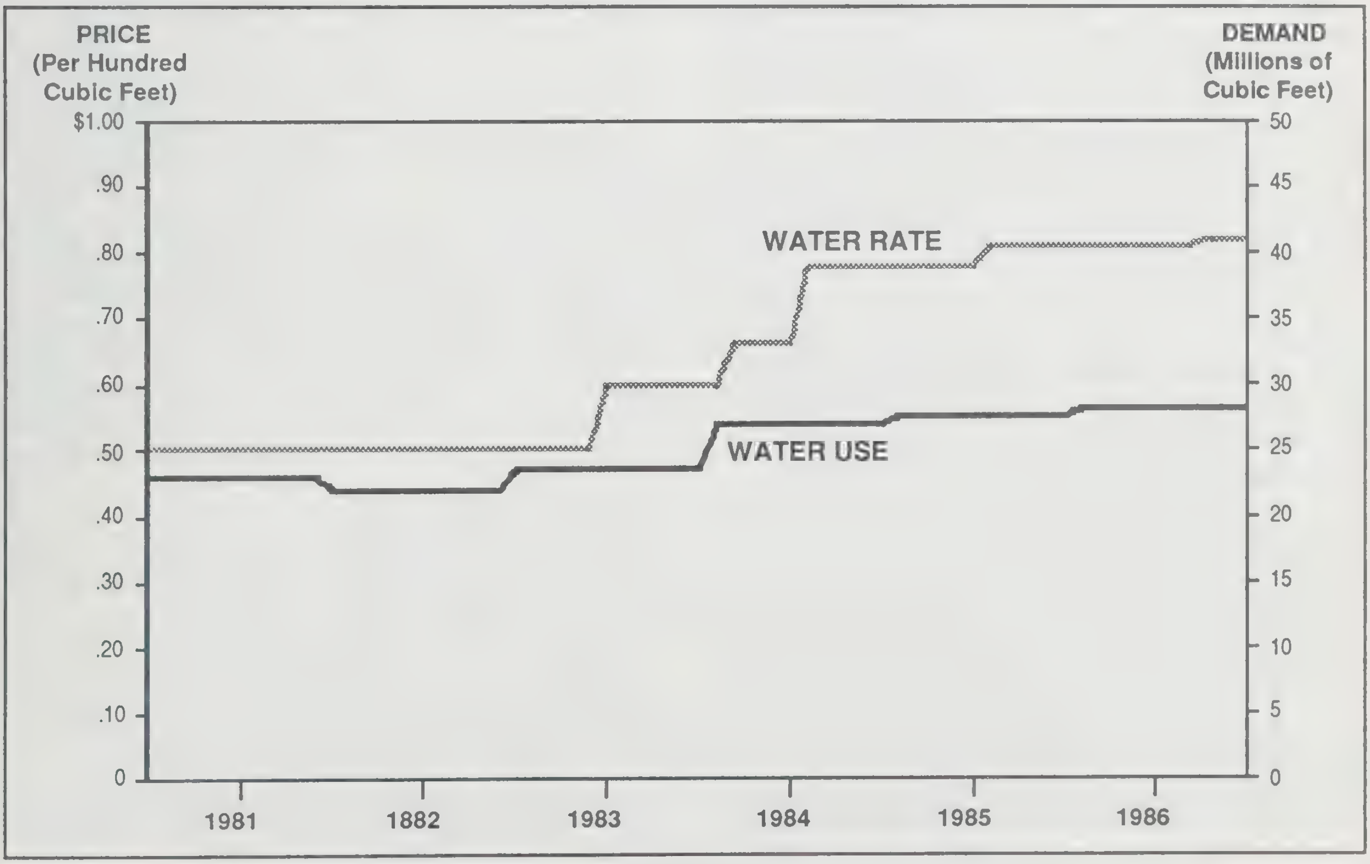
## Alamo Demonstration Garden Water Use

Figure III-13




## Price vs. Demand Elevated Zones

Figure III-14



## Urban Water Management Plan Water Conservation Program

Figure III-15

| WATER CONSERVATION MEASURES | IMPLEMENTATION STATUS | | |
|---|---|---|---|
| | FULLY IMPLEMENTED | PARTIALLY IMPLEMENTED | NOT YET IMPLEMENTED |
| A. **WATER SAVING DEVICE DISTRIBUTION** Offer 20,000 retrofit kits (first year) at EBMUD business offices and through water audits including low-flow showerheads and water bags for toilets to increase the number of water-saving devices installed in single and multi-family residences as well as commercial, institutional* and industrial premises. | X | | |
| B. **WATER AUDITS** Offer to inspect water-use practices of existing industrial, commercial, institutional and single and multi-family residential customers and make recommendations for improved efficiency. Offer retrofit kits where applicable. Primary focus will be on indoor and process water use. | | X | |
| C. **LANDSCAPE CONSULTATION** Introduce all existing and new customers to low water-using landscape concepts and materials through mailings and personal contact. Customers will be offered technical assistance and District literature. | | X | |
| D. **LANDSCAPE REBATE** Offer a rebate to existing customers to provide an incentive to install water-conserving landscapes that meet District criteria (single family up to $300 and multi-family up to $5000, based on landscaped area). | | | X |
| E. **SYSTEM CAPACITY CHARGE (SCC)** Offer discounts on the SCC paid by all new customers who exceed code requirements for showerheads and toilets. | | | X |
| F. **LANDSCAPE WATER USE EFFICIENCY IN NEW DEVELOPMENTS** Establish landscape water-use efficiency regulations for new residential, industrial, institutional and commercial developments through cities and counties or by the district, if necessary; or Offer incentives to install water-conserving landscapes that meet District criteria through an SCC discount or rebate program. | | X | |
| G. **PUBLIC INFORMATION** Provide public information programs such as landscape booklets and brochures, exhibits, etc. to support and promote water conservation by demonstrating the methods for conserving water and the benefits of efficient water use. | X | | |
| H. **SCHOOL EDUCATION** Increase the promotion of wise water use habits and expand appreciation for water as a limited natural resource in primary and secondary schools. | X | | |
| I. **SUPPORT ACTIVITIES** Establish a Landscape Advisory Committee to provide technical support and act as liaison with the professional landscape community. | | | X |
| J. **DISTRICT WATER USE ACTIVITIES** Develop procedures to review District landscaping plans and retrofit existing District landscape to assure efficient water use. | X | | |
| K. **WATER PRICING STUDY** Study water conserving rate structures as a means of increasing water use efficiency. | X | | |
| L. **PRESSURE REDUCTION STUDY** Identify areas of high water pressure (greater than 80 psi) and investigate the feasibility of a pressure reduction program. | | | X |

*Institutional includes public agencies.

other planned multi-unit developments. The District has been monitoring water use by these customers; however, it is too early to tell how much water is being saved.

In 1987, the District purchased 17,000 kits for $50,000; 12,000 retrofit kits were made available to customers through the District's business offices. In January 1988, District staff distributed 5,000 kits door-to-door to customers in selected areas. The District will monitor the water use of these customers and follow-up with surveys to determine customer satisfaction with the devices.

The most recent kits include showerheads with flow rates between 1.8 gpm and 2.7 gpm. If these kits are installed in housing units built prior to 1978, there is a potential for savings of about 9.8 gal/capita/day. This is currently equivalent, on average, to 27.1 gal/day for single family homes and 18.6 gal/day for multi-family developments. However, since 1978, California law has required new housing to include low-flow showerheads (2.75 gpm) and low-flush toilets (3.5 gal/flush). Therefore, the showerheads included in the kits will save little additional water (about 3 gal/capita/day) in homes built since 1978.

Another factor to consider with the retrofit kits is that not all the kits distributed are actually installed. Furthermore, some devices may later be removed due to dissatisfaction. The District is currently evaluating the rate of use and satisfaction with retrofit devices distributed to customers. The retrofit kits may be most effective as a response to drought conditions. The kits can be quickly distributed and installed in homes during a drought (the District has distributed 50,000 kits during the current drought).

**Water Audits.** The water audit program was implemented in 1987. The purpose of the program is to examine water use practices, detect leaks, and make recommendations for improved efficiency for both inside and outside water use. Approximately 100 audits have been conducted, mostly for commercial customers, multi-family residential housing, and other planned unit developments.

The District plans to conduct 300 audits per year, keeping track of customers who receive audits and monitoring their use for water savings. Future analysis will determine if the audits performed to date have been effective in reducing water use.

**Landscape Consultations.** The District offers free landscape consultations to familiarize customers with low water use landscapes and associated benefits and to provide technical assistance. During the consultations, the District will review landscaping plans, recommend plant material, and provide information on irrigation. Approximately 50 landscape consultations were conducted in 1987, half with multi-family residential and other planned unit developments and half with single family residential customers, including homeowner associations.

**Landscape Rebate.** This measure has not been implemented, however, a pilot rebate program is proposed as part of the additional water conservation measures discussed later in this chapter.

**System Capacity Charge (SCC) Discount.** This measure has not been implemented. See discussion in Appendix F.

**Landscape Water Use Efficiency in New Developments.** In August 1987, the District imposed stringent landscape design criteria on three annexations to the District's service area. These developments will be required to conform to the landscape guidelines as a condition of water service. Shortly before that time, the District provided the cities and counties within the EBMUD service area with "model" guidelines establishing criteria for landscapes in new developments. The guidelines include criteria on reviewing landscape plans, limiting lawn areas, types of plant material, and irrigation systems. The guidelines are intended to reduce outside water use by 25 percent in affected new developments; however, the actual savings are uncertain. To date, all but five cities within the service area have adopted modified versions of the guidelines. The District is continuing to encourage these cities to adopt similar guidelines.

As a practical matter, the guidelines have yet to be adopted and enforced District-wide.

**Public Information.** The following is a list of public information material designed and produced by the District.

- Landscape Book. In 1986, the District produced 10,000 copies of a 100-page book with color photos describing water conserving plants and landscapes of the Bay Area. The cost was $80,000. The books are available to the public for $8.00.

- Landscape Brochure. In 1987, the District produced 150,000 copies of a landscape brochure which identifies low water using plants. The brochure cost $20,000 to produce and is available to customers for free.

- Landscape Video. The District is currently working with other agencies to produce a landscape video to provide tips on low water using landscaping.

- Exhibits. The District has two portable water conservation exhibits which are displayed in public buildings, at community events, and at conferences.

- Speakers Bureau. EBMUD provides speakers from its staff to give 50 to 100 presentations each year on water conservation and other topics.

- Water Conservation Activity Center. In September 1986, a Water Conservation Activity Center was established at the Alamo business office. The center includes a demonstration garden, a conservation exhibit, and provides information on water saving devices and low water using landscapes.

**School Education.** EBMUD has been involved in the development of educational material since the early 1970's. EBMUD has helped in the development of educational software which will teach students about water and its efficient use.

**Support Activities.** The District has hired landscape architects to assist in the development of landscape guidelines, conduct landscape consultations, review landscaping plans, and advise customers on irrigation systems.

**District Water Use Activities.** The District currently meters its own water use at all facilities. In addition, all landscaped areas of District facilities are now planted with low water using plants, and the District is currently formulating specific criteria for landscaping at District facilities.

**Water Pricing Study.** In 1987, the District conducted a water pricing study to evaluate the effects of price on water demand. The study found no statistically significant relationship between price and water use. The study examined water use by customers within the service area whose water rates increased from 30 to 50 percent with the imposition of an elevation surcharge in 1983.

**Pressure Reduction Study.** The District has not yet conducted a study to identify areas of high water pressure (greater than 80 psi) and investigate the potential feasibility of a pressure reduction program.

IRRIGATION UPGRADE PILOT STUDY

The District has collected data concerning the water savings in its demonstration gardens due to efficient irrigation and water conserving plant material. However, water savings resulting from irrigation systems upgrades is presently unknown. In 1988, the District plans to conduct an irrigation upgrade pilot study in cooperation with other public agencies. By studying the irrigation practices of the 100 largest irrigators, the District will determine landscape water efficiencies and analyze potential benefits from incentive/rebate programs. The 100 largest irrigators comprise approximately 7.5 percent of District outdoor use.

Several studies will be conducted during the course of the pilot program to determine the feasibility, method, and costs and benefits of an incentive/rebate program. The studies will:

- Determine potential water savings and cost effectiveness of upgrading existing automatic irrigation systems.

- Evaluate the current water use practices of the District's 100 largest irrigators to determine what improvements, if any, can be made.

- Compare potential landscape irrigation savings of single family households with non-single family customers.

### Water Reclamation

Reclamation is the process of collecting and treating wastewater to produce water of suitable quality for additional beneficial uses. In California, approximately 240 water reclamation plants serve over 380 users with 65 billion gallons of reclaimed water per year. Of this amount, 80 percent is used for agricultural and landscape irrigation, 11 percent for groundwater recharge, 4 percent for industrial cooling and washdown, 3 percent for recreational impoundments, and the remainder for miscellaneous activities such as dust control.

Over the past several years, the District has been investigating the feasibility of wastewater reclamation as a way to make the most efficient use of the high quality Mokelumne River supply, adding to its long-term supply. The result has been the implementation of programs that currently save approximately 4.7 million gallons per day (MGD) of potable water per year. These programs are summarized in Figure III-16. Several additional projects are currently proposed to increase this amount by another 4.9 MGD over the next several years, and are discussed in a later section.

## Reclamation Projects

Figure III-16

| PROJECT | DESCRIPTION | STATUS | ANNUAL WATER SAVINGS (MGD) |
|---|---|---|---|
| EBMUD Wastewater Treatment Plant | Reclaimed wastewater for landscape irrigation and general washdown at the facility. | Standard practice | 0.54 |
| | Secondary effluent used for industrial cooling of power generation station and cooling of compressors at oxygen production plant. | Standard practice | 1.5—2.0 |
| EBMUD Filter Plants | Reclaimed backwash water from District filter plants. | Standard practice | 7.0 |
| Richmond Golf Course | Reclaimed wastewater from West Contra Costa Sanitary District for irrigation of the Richmond Golf and Country Club. | Service started in 1984 | 0.16 |

CURRENT WATER RECLAMATION PROJECTS

**EBMUD Wastewater Department Activities.** In 1971, the District constructed the Process Water Plant at its Wastewater Treatment Plant to provide tertiary treatment of wastewater for on-site irrigation and plant washdown uses. This plant has a capacity to treat up to 1 MGD. The average annual production is 0.54 MGD (605 acre-feet/year). Additionally, secondary effluent is used for industrial cooling of the power generation station and for cooling of compressors at the oxygen production plant. The quantity of secondary effluent is on the order of 1.5 to 2.0 MGD (1680 to 2240 acre-feet/year).

**Filter Plant Washwater Reclamation.** Facilities for reclaiming filter backwash water from most of the District's filter plants were constructed in the late 1970's in order to comply with federal discharge requirements. The National Pollutant Discharge Elimination System (NPDES) permit required that the majority of suspended solids be removed from the washwater prior to discharge into a receiving stream. The treatment plants operate sedimentation facilities to collect the solids and recover the clarified overflow. Four of the six plants recycle the overflow through the normal treatment process rather than discharging it to the receiving stream. The operation of filter plant reclamation facilities saves the District approximately 2.0 MGD (2240 acre-feet/year). The ability to treat and reclaim about 5 MGD (5,600 acre-feet/year) of washwater at Orinda filter plant will be available in 1988; however, because direct discharge of washwater to the San Pablo Creek replenishes the San Pablo Reservoir no additional water savings will be realized. Facilities currently under construction at Orinda will allow reclaimed water to be used at the filter plant. Although normal discharge will be to the creek.

**Richmond Golf Course.** In 1984, the West Contra Costa Sanitary District (WCCSD) began supplying reclaimed wastewater for summertime irrigation to the Richmond Golf and Country Club. One hundred and fifty acres are irrigated, resulting in an estimated average annual consumption of 0.16 MGD (185 acre-feet/year). Peak monthly use during the irrigation season has reached 0.61 MGD. As water purveyor, EBMUD was instrumental in implementing this project and is responsible for overseeing its operation.

The economic incentive for the user to switch to reclaimed water was a significant factor in the decision to proceed with this project. The user pays a small amount for operation and maintenance of the reclaimed water system (pumping, coliform monitoring, and reporting) and for the backup potable water supply, which is always available. The wastewater also provides all the fertilizers needed to promote turf growth. The cost to the user averages approximately $45/acre-foot. At this price, the District is reimbursed for all costs.

Factors contributing to the relatively low cost of this particular project are the close proximity of the wastewater treatment plant (two miles) and the availability of an existing abandoned pipeline, which is used for most of this distance. In addition, the high quality of WCSSD effluent and the reliability of the treatment processes at this plant ensure that the reclaimed water meets Department of Health Services (DOHS) coliform standards for irrigation use with no additional treatment, although a standby chlorination unit is immediately available.

## POLICY ON THE SALE OF RECLAIMED WATER

In the past, the District addressed the pricing of reclaimed water on an individual project basis. This was because each project is unique in terms of its source, treatment requirements, and the District's role in project implementation.

Because reclaimed water is more expensive (2-3 times the cost on a unit basis of new projects), the District's Water Conservation and Development Fund made up of revenues taken from new connections will finance these projects. The fund was established by EBMUD to assist in the financing of measures to increase water supply availability. This fund may be used to implement water conservation measures or develop wastewater reuse or water supply improvement projects. This approach is consistent with the recently adopted policy on the sale of reclaimed water shown in Figure III-17. The policy provides a standardized approach for setting a price for reclaimed water based on the unique water quality and operational factors of each project. The primary goal is to recover District cost to the extent without increasing the overall cost to the user. The reclaimed water policy also states that when reclaimed water is available, and suitable for use, it should be substituted for potable water in non-potable applications.

### Policy on Sale of Reclaimed Water

Figure III-17

**IT IS THE POLICY OF THE EAST BAY MUNICIPAL UTILITY DISTRICT TO:**

Maximize the efficient use of the existing potable water supply system by supporting the development of reclaimed water projects.

Establish a reclaimed water price that will:

1) generate sufficient revenues, when combined with connection charge revenues, to recover all District costs over the life of the project,
2) result in no net increase in the overall cost to the user for water, and
3) be a fixed percentage of potable water cost, allowing for inflationary increases over the life of the project.

Substitute reclaimed water, when available, for potable water in non-potable applications (irrigation, process cooling, etc.)

## AVAILABILITY OF SUPPLY

The District has the legal right and capacity to divert up to 325 MGD from the Mokelumne River, an amount available in most years.

### Supply Limits

Conditions which restrict the District's ability to use its legal right of 325 MGD include:

- Upstream water use by prior rights holders.
- Downstream water use by riparian and senior appropriators and other downstream obligations.
- Drought, or less than normal rainfall.
- Emergency outage.
- Achievable demand reductions during reduction/loss of supply.

These conditions which restrict the supply available from the Mokelumne are illustrated in Figure III-18.

### Demands on the Mokelumne River

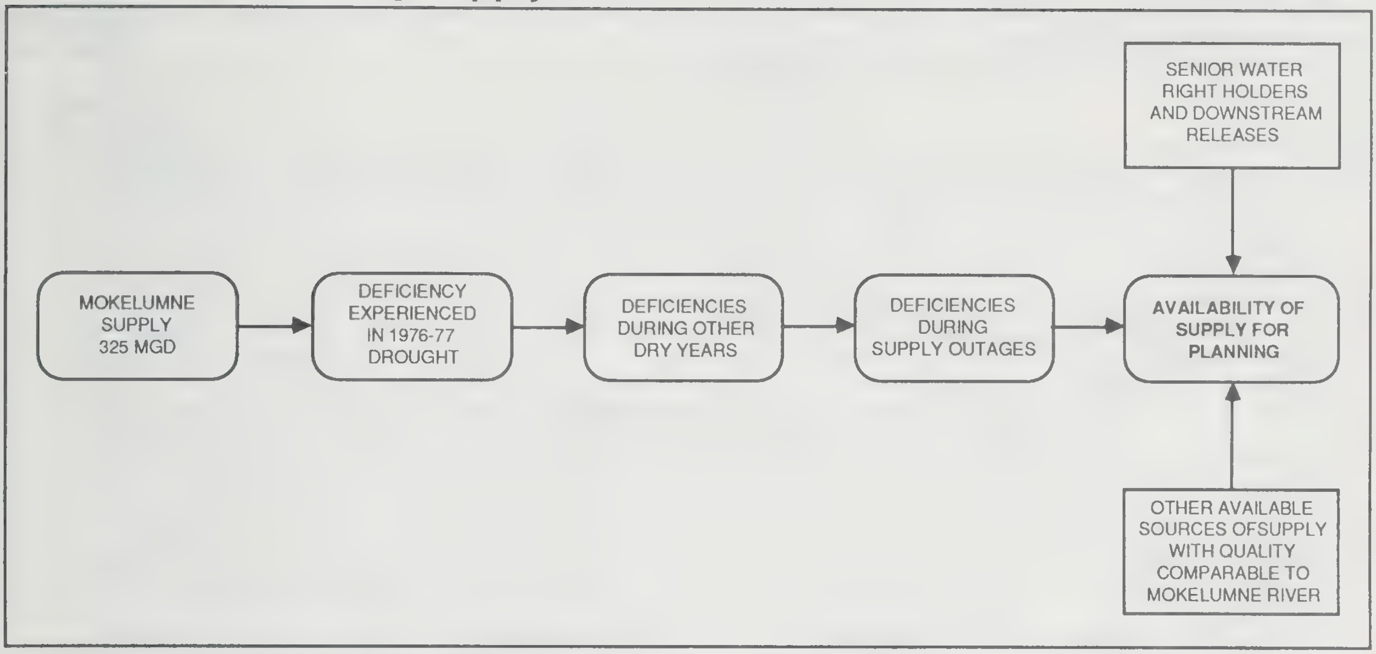
EBMUD's water supply from the Mokelumne River is subject to the water rights of other users. The District's position in the hierarchy of Mokelumne water users is determined by a variety of agreements between Mokelumne right-holders, as well as by the appropriation permits and licenses which have been issued, pre-1914 rights and riparian rights. Figure III-19 shows the hierarchy or relative priorities of rights and other flow commitments on the lower Mokelumne basin. Demands on the Mokelumne River by prior rights holders and riparian rights are anticipated to increase by the year 2020 thereby reducing the firm yield of the District's Mokelumne supply. The firm yield of the District's Mokelumne supply is defined as the maximum continuous rate of diversion that can be derived from the project through the most critical period of record by making maximum use of available storage. The firm yield of the District's Mokelumne supply system is projected to decline from 215 MGD to 198 MGD.

### Drought

In most years, the full 325 MGD allotment is available. However, during drought periods of two or more years, the delivery of water from the Mokelumne can be as low as 198 MGD. As discussed later in this chapter, demand is projected to increase from the current 220 MGD to 270 MGD in 2020, and the firm yield is projected to decline from 215 MGD to 198 MGD at the same time. When demand

## Conditions Restricting Supply

Figure III-18




exceeds the firm yield, the District must impose mandatory rationing unless adequate backup storage is available. In 1985, the District responded to the increasing risk of shortage by adopting a Water Supply Availability and Deficiency Policy.

### POLICY ON WATER SUPPLY AVAILABILITY AND DEFICIENCY

Because of the drought situation in 1977, the District adopted a policy on Water Supply Availability and Deficiency in May 1985. It recognized that planning on taking a deficiency in the water supply during drought is a prudent approach because (1) such deficiencies are infrequent, (2) the magnitude of the deficiencies and thus the hardship on customers can be limited, and (3) it allows the supply to be put to a greater beneficial use in most other years when the full entitlement of 325 MGD is available from the Mokelumne River.

The policy established criteria for evaluating the adequacy of the District's water supplies and to provide for the following:

- Annual review of the water supplies available for the current and following year to meet the demand of EBMUD's customers.

- Annual review of the water supplies available for the long-term to meet projected increases in demand.

- Case-by-case review of the water supplies available when considering decisions on requests for extension of service to annexations beyond the ultimate boundary and replacement supplies to other water agencies.

The availability of the Mokelumne supply to customers is dependent on a large part to (1) the timing and severity of rationing imposed upon customers during a drought or outage and (2) the amount of storage maintained for emergency standby during a disruption or outage. The policy limits the rationing during dry years to the 39 percent reduction in demand actually experienced by the average customer during the 1977 drought. (It should be noted that in 1988 this percentage would be 35 percent to equal the hardship experienced by customers in 1977.) It assumed that customers would voluntarily reduce their water use by 25 percent in the six months prior to the year of rationing. The District maintains a minimum of 120 days of standby storage for short-term supply outages which is discussed in detail in Chapter II. The full text of the District's policy is shown in Figure III-20.

### POLICY ON SALE OF SURPLUS WATER

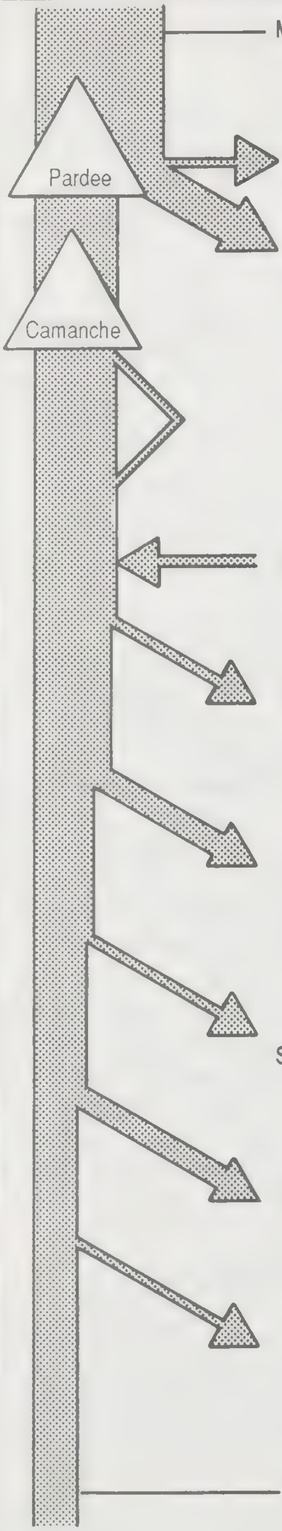
Over the years, EBMUD has received a number of requests to supply surplus Mokelumne River water to adjacent areas. As a result, in October 1986, the District adopted a policy on the Interruptible Sale of Surplus Water.

EBMUD will consider requests for water supplies outside the ultimate boundary on an individual basis in accordance with established policies and

# Mokelumne River Flow Downstream of Pardee

## (Acre-Feet per Year)

Figure III-19




| | WATER YEAR 1979 (typical) | AVERAGE | RANGE | MAXIMUM ENTITLEMENT |
|---|---|---|---|---|
| Mokelumne Hill Gage | 678,300 | 735,500 | 150,300—1,788,090 | —— |
| Jackson Valley Irrigation District | 3,000 | 1,500 | 0—3,800 | 5,000 |
| EBMUD Aqueduct Draft | 187,100 (= 167 MGD) | 196,500 (175 MGD) (20 years) | 130,600—245,700 (117 MGD—219 MGD) (Last 20 years) | 364,000 (= 325 MGD) |
| Fish Hatchery Releases | 16,200 | 18,300 | 5,900—23,300 | 13,000 |
| Intermediate Inflow | 7,100 | 6,600 | 80—13,900 | —— |
| North San Joaquin Water Conservation District* | 7,400 | 7,400 (without 1976 and 1977) | 4,600—9,500 (0 in 1976 & 77) | 20,000 |
| Woodbridge Irrigation District* | 76,200 | 95,100 | 51,400—121,700 | 116,700 (= 60,000 Permanent Regulated + 56,700 Interim) |
| Riparians and Senior Appropriators* | 14,600 | 13,700 | 10,100—18,200 | 20,618 |
| Channel Losses* | 56,700 | 80,000 | 32,700—108,700 | —— |
| City of Lodi* | 0 | 0 | 0 | 3,600 (If triggered by Lodi Decree) |
| Woodbridge Gage | 341,700 | 453,800 | 15,800—1,559,600 | —— |

*Also provides instream flows for fish.

## Policy on Water Supply Availability and Deficiency

Figure III-20

IT IS THE POLICY OF THE EAST BAY MUNICIPAL UTILITY DISTRICT TO:

A. Evaluate the availability of the District's water supplies (supplies of the same or similar quality to that of the Mokelumne River supply) and determine the acceptable maximum level of average annual demand for the District's service area based on limiting the water supply deficiency in a repeat of 1976-77 hydrologic conditions to the percentage reduction in demand actually experienced by the average customer during the period of water rationing in 1977.

B. Review and report on the current and long-term adequacy of the District's water supplies annually on or about April 15. The report shall include the acceptable maximum level of demand, projected water requirements, and the estimated surplus in supplies over and above the projected requirements.

C. Make projections of average annual demand for evaluating the adequacy of water supplies assuming:

- Water service will be provided in response to reasonable requests for service to properties located within the District's service area.
- Annexation of property within the District's ultimate boundary will be considered pursuant to normal District procedures in response to reasonable requests for service.
- A water conservation program will be implemented as provided in the District's Urban Water Management Plan.

D. Review and report on the long-term adequacy of the District's water supplies when considering case-by-case decisions on requests for replacement supplies which would increase the average annual demand by one percent or more; or, annexation beyond the ultimate boundary.

- A request for annexation beyond the ultimate boundary for extension of water service to new development will be considered only if it represents the most practical and feasible method of obtaining service and the acceptable maximum level of average annual demand is not exceeded.
- A request for a replacement supply for another water agency will be considered only if the other agency maintains a reliable alternative source of supply. This requirement may be waived at the discretion of the Board of Directors when the replacement supply is needed because of serious water quality problems or for public health reasons.
- District Policy on Effects of Extension of Water Beyond the Ultimate Boundary shall be applicable in each case.

E. Consider appropriate demand management measures and/or implementation of a supplemental supply if existing supplies are found to be inadequate. In the event that demand management measures and the availability of supplemental supplies fail to result in a supply adequate to meet projected demand, equitably allocate the limited amount of excess supply in consultation with affected cities and counties.

Reference: Board Resolution 31,246, May 14, 1985

procedures. The estimated quantity of surplus water will be determined each year prior to May 1 in accordance with the provisions of the Policy on Water Supply Availability and Deficiency. Priority will be given to purchasers whose existing supply does not meet primary drinking water standards, and the charge for water will be based on the costs of operation and maintenance of the Mokelumne system plus a capital cost component. The full text of the District's policy is shown in Figure III-21.

The City of Brentwood is currently receiving supplies of surplus Mokelumne water (1.25 MGD maximum) to alleviate water quality problems and has requested a new agreement for 2.5 MGD. Contra Costa Water District has also requested 50 MGD of EBMUD surplus water for the same reason, and the District serves four additional customers whose combined use is less than 0.5 MGD of surplus water.

### Supply Disruption

The risk of a supply outage due to an aqueduct failure in the Delta has been discussed in Chapter II. The required time to bring the aqueducts back into service could be 17 months or more, as suggested in earlier studies which show 33 months. The risk of a supply disruption is more critical than a drought. In a

## Policy on Interruptible Sale of Surplus Water

Figure III-21

IT IS THE POLICY OF THE EAST BAY MUNICIPAL UTILITY DISTRICT TO:

Respond to requests from governmental entities for delivery of water by entering into contracts for the sale of surplus water on an interruptible basis.

Interruptibility. The sale of surplus water, as governed by Section 12804 of the Municipal Utility District Act, is by definition interruptible. Provisions of this policy designed to further assure interruptibility of delivery include the procedure by which purchasers must request delivery quantities each year for the District's determination of availability, the requirement that each purchaser maintain an adequate backup supply, and the provision for cancellation of the contract by either party.

Water Availability. The estimated quantity of surplus water will be determined each year prior to May 1, in accordance with the provisions of the Water Availability and Deficiency Policy. The sale of surplus water must have no adverse impact on the availability of water to customers within the District. The District reaffirms that its first obligation is to serve customers within the District.

Quantity To Be Sold. The total quantity to be sold each year will be limited to the quantity of surplus water estimated to be available. Each purchaser shall pay for a minimum quantity of not less than 20 percent of the maximum annual quantity to be delivered under its contract, provided that the minimum quantity is available. Annual requests for delivery quantities shall be submitted to the District by April 1 each year. If the total of all requested deliveries exceeds the water estimated to be available, the allocation to each purchaser will be proportionate to the average of the actual quantities of surplus water used in the preceding three years or the average of the minimum quantities paid for in the same period, whichever is greater, subject first to the priority given below. If water is unavailable to a purchaser in any year, then EBMUD shall have no obligation to deliver water under that contract for that year (May 1 to April 30).

Priority. In the allocation of the available quantity of surplus water each year for delivery under existing contracts or new contracts, the first priority shall be given to the requirements of purchasers whose existing supply does not meet primary drinking water standards.

Backup Supply. Each purchaser shall maintain a backup supply adequate to meet the demand in its service area when the delivery of surplus water is reduced or interrupted.

Costs. The charge for water will be based on the costs of operation and maintenance of the Mokelumne system including the costs of pumping and lost power revenues, plus a capital cost component equal to a proportionate share of the District's original cost of constructing the existing facilities. Purchasers shall pay the one-time cost of installing the connecting facilities and any subsequent costs of repair or removal.

Cancellation. A contract may be cancelled by either party on July 1 of any year provided that a minimum of 45 days' advance written notice is given.

Water Conservation. Each purchaser shall provide by April 1 of each year an updated report on water management in its service area to assure that the purchaser's water conservation efforts will achieve improvements in the efficiency of water use similar to those adopted by the District.

Supplemental Water Supply. Each purchaser shall cooperate with and assist the District in obtaining increased quantities of water equivalent in quality to that being delivered from the Mokelumne River, including but not limited to administrative, legislative, and planning activities.

Reference: Policy 53/Board Resolution 31,735, October 7, 1986

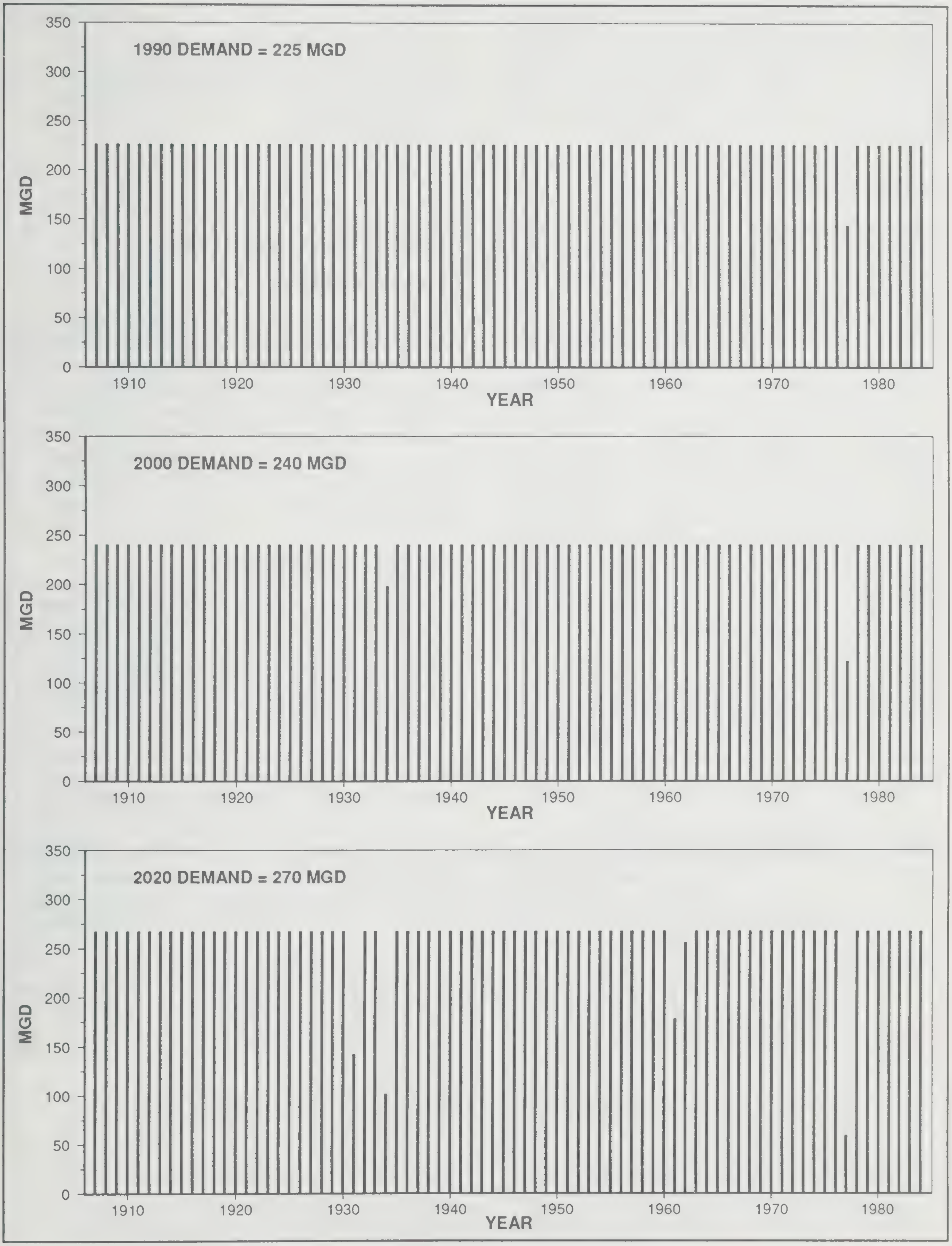
drought, the availability of the Mokelumne supply is reduced — in an outage, the supply is not available. It is true, particularly as Delta islands become progressively unstable, that emergency supplies from the Delta may be unusable due to sea water intrusion resulting from several levee failures.

### Recent Experience Changes Availability

The need to make greater reductions in dry years as demand increases is illustrated in Figure III-22. Minimizing such reductions by keeping demands as low as possible could be difficult. For instance, EBMUD's effort in 1987 to have customers voluntarily reduce demand by 12 percent during the last half of the year did not achieve that result, although it may have kept demand from increasing more. Obviously, the intended results of a water conservation program are not always reliable and predictable. Public acceptance of the need to conserve and the conservation measures are important factors.

## Mokelumne Supply Availability

Figure III-22



As explained in the security discussion, EBMUD experience and studies show that water pricing is not effective as a means of reducing normal year demand. On the other hand, the 1977 experience with water rationing showed that the threat of severe financial penalties for excessive use coupled with the declaration of an emergency can be effective on a short-term basis.

### Drought Limitations

District water users, particularly industrial customers, cannot reduce water use as much as they did in 1977. The level of hardship experienced by large and small landscape irrigators during the 1976/77 drought resulted in customer losses of about $115 million in 1988 dollars. To reduce the level of hardship and user costs, drought restrictions should be reduced. In addition, industrial and institutional customers became more efficient in their water use by installing new equipment and devices, repairing leaks, and modifying processes. This increased efficiency, together with more efficient plumbing fixtures in new construction and increased use of low water use landscaping, means that a rationing program today to achieve a 39 percent reduction will cause a much greater hardship than it did in 1977. As water conservation efforts continue to improve water use efficiency, the same reduction will become even more difficult. Figure III-23 indicates that demand reductions in 1988 would be only 35 percent.

As further water conservation and reclamation measures are implemented, water use efficiency will continue to increase. Therefore, the planned maximum reductions for the various categories of customers should be reduced.

In light of this and also to reduce the severity of rationing to a more reasonable level, the planned maximum reductions for the various categories of customers could be reduced as shown in Figure III-23 with an overall maximum reduction of 25 percent. Figure III-24 shows the effect on availability of the Mokelumne supply if the limit on rationing is reduced from 39 to 25 percent.

## PROJECTED WATER USE

### Service Obligation

State law requires EBMUD to provide water service under reasonable conditions to all customers located within its service area and annexed territory within its ultimate boundary if it is reasonably feasible to do so. EBMUD has tried to anticipate the needs of its customers and assure that the water supply system is adequate, that service is reasonable, and that development and redevelopment which is served meets the planning requirements of all cities and counties.

### Water Demand Projections

Water demand projections are based on customers' water use patterns and projected data from various sources such as the Association of Bay Area Governments (ABAG), the California Department of Finance, and planning agencies in each city and county in the EBMUD service area.

Projections of residential water use are based on housing and population projections and data on residential water use patterns. Figure III-25 shows the

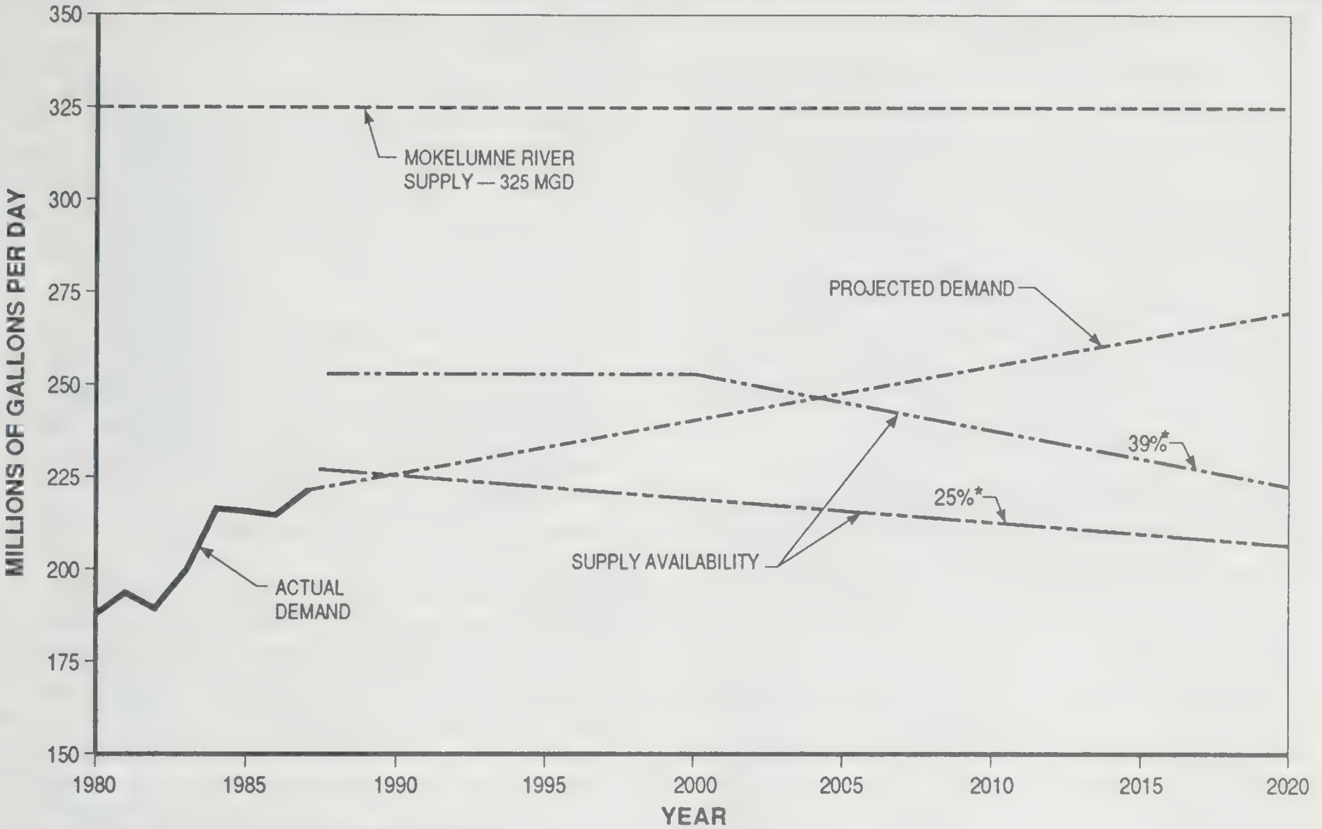
## Demand Reduction in Drought

Figure III-23

| CUSTOMER CATEGORY | ACTUAL DEMAND REDUCTION IN 1977 | ACHIEVABLE REDUCTION IN 1988 | ACHIEVABLE REDUCTION IN 2020 | REDUCED SEVERITY IN DROUGHT |
|---|---|---|---|---|
| Residential | | | | |
| — Single family | 49% | 44% | 42% | 35% |
| — Multi-family | 23% | 23% | 20% | 15% |
| Commercial and Institutional | 39% | 34% | 28% | 25% |
| Industrial | | | | |
| — Petroleum | 18% | 12% | 0% | 0% |
| — Other | 29% | 9% | 5% | 5% |
| Parks, Golf and Cemeteries | 55% | 47% | 35% | 30% |
| OVERALL | 39% | 35% | 31% | 25% |

## Supply Availability

Figure III-24




*Limit on rationing in second year of drought like 1976-77.

projected population trend in the EBMUD service area. Figure III-26 shows the projected housing requirements in the EBMUD service area. Increase in housing is projected to occur throughout the EBMUD service area with most of the increase (about 60 percent) occurring in the western region.

Future water demands within the present EBMUD service area and ultimate boundary have been calculated for the period 1986 through 2020. The ultimate boundary is shown in Figure III-27A and the demands are shown in Figure III-27B. Figure III-28 shows water use for new housing units.

The planning level of projected water use between 1986 and 2020 is taken as the mean of the high and low projections plus one standard deviation of 10 MGD to reflect uncertainty due to the short-term fluctuations discussed above.

Water requirements are the projected water demand less the savings that result from water conservation and water reclamation programs already in place or underway. The present and additional water conservation program is expected to reduce water demand by about 3 percent (about 6 MGD) by the year 2020. Water reclamation projects are expected to save an additional 5 MGD by the year 2020. The water conservation and water reclamation programs are described in the alternatives section of this chapter. The expected water savings from a fully effective water conservation and water reclamation program is about 11 MGD (5 percent) by the year 2020.

In the year 2020, the demand is expected to be in the range of 247 MGD to 294 MGD depending on the effectiveness of the water conservation program. The planning level of demand assumes that the current water conservation measures will be implemented successfully and achieve the estimated water savings. Therefore, the planning level of demand is 270 MGD in 2020.

### Existing Terminal Storage Limitations

A fixed amount of storage space is available for standby in the existing terminal reservoirs. As demand increases, the storage required to maintain 120 days of supply through a drought also increases. Consequently, the storage available for use during the drought decreases or consumer demand is significantly reduced. Sometime between 1995 and 2005 additional terminal storage or additional supplies are

needed to ensure that customers do not have to reduce demand during a drought by more than 25 percent.

When demand exceeds 252 MGD, the storage required to maintain the 120 days of supply will exceed the total standby storage space available in the existing terminal reservoirs. Figure III-29 illustrates that, at this point, additional terminal storage will be required to maintain the 120-day standby supply without sacrificing storage allocated to regulation. Both the regulation storage and the 120-day standby storage requirements are independent of the source of supply. Therefore, storage for these uses is needed with the Mokelumne River supply and regardless of implementation of any new supplies.

## Areas Served by EBMUD

Figure III-25

| CITY/COMMUNITY | 1985 POPULATION[1] | 2000 POPULATION |
|---|---|---|
| **Alameda County** | | |
| Alameda[2] | 70,400 | 73,700 |
| Albany[2] | 15,100 | 15,100 |
| Berkeley[2] | 106,600 | 103,300 |
| Castro Valley[3] | 45,500 | 50,500 |
| Emeryville[2] | 5,000 | 6,600 |
| Hayward[4,5] | 14,900 | 19,500 |
| Oakland[2] | 352,100 | 361,500 |
| Piedmont[2] | 10,400 | 10,200 |
| San Leandro[4] | 82,100 | 89,900 |
| San Lorenzo[3] | 20,500 | 20,000 |
| Subtotal | 722,600 | 750,200 |
| **Contra Costa County** | | |
| Alamo-Blackhawk[3] | 13,200 | 17,500 |
| Danville[4] | 32,100 | 41,600 |
| El Cerrito[4] | 29,000 | 27,500 |
| Hercules[4] | 9,700 | 18,400 |
| Lafayette[4] | 22,600 | 22,100 |
| Moraga[4] | 15,000 | 16,600 |
| Orinda[4] | 17,300 | 16,600 |
| Pinole[4] | 24,600 | 25,600 |
| Pleasant Hill[4,5] | 5,400 | 5,800 |
| Richmond[4] | 90,700 | 101,200 |
| Rodeo-Crockett[3] | 11,300 | 12,000 |
| San Pablo[4] | 24,900 | 24,700 |
| San Ramon[4] | 25,500 | 38,900 |
| Walnut Creek[2,5] | 42,100 | 44,300 |
| Subtotal | 363,400 | 412,800 |
| **TOTAL** | 1,086,000 | 1,163,000 |

[1]1985 estimate based on ABAG projections
[2]City
[3]ABAG Subregional Study Area
[4]City Sphere of Influence
[5]City not entirely served by EBMUD; population shown is served by EBMUD. For these cities, year 2000 projection assumes portion served by EBMUD grows at same rate as entire city.

## ALTERNATIVES TO REDUCE WATER SHORTAGES

### Do Nothing

To do nothing would mean a continuation of the problem of water shortages during droughts with an increasing severity of rationing as demand increases in the future. When demand exceeds about 240 MGD around the year 2000, the necessary percentage reduction in demand will be greater than the 39 percent achieved in 1977.

Delta water may also have to be used. Chapter IV discusses in detail EBMUD's experience with Delta water during the 1976-77 drought. Because Delta water quality would be even lower during droughts, the potential health risks of using Delta water must be considered.

### Water Conservation Alternative

This section summarizes the District's current water conservation activities and establishes the "Base Case" for water conservation already in effect at EBMUD. An alternative conservation program consisting of the base program plus additional measures is also presented. The additional measures proposed are those found to be most reasonable, feasible, and publicly acceptable. Other measures which have been considered are identified in Appendix F.

An earlier section provided background information on the development of water conservation efforts at EBMUD. The Base Case program contained in this section describes the current status of ongoing measures with projections of future costs and water savings for each measure.

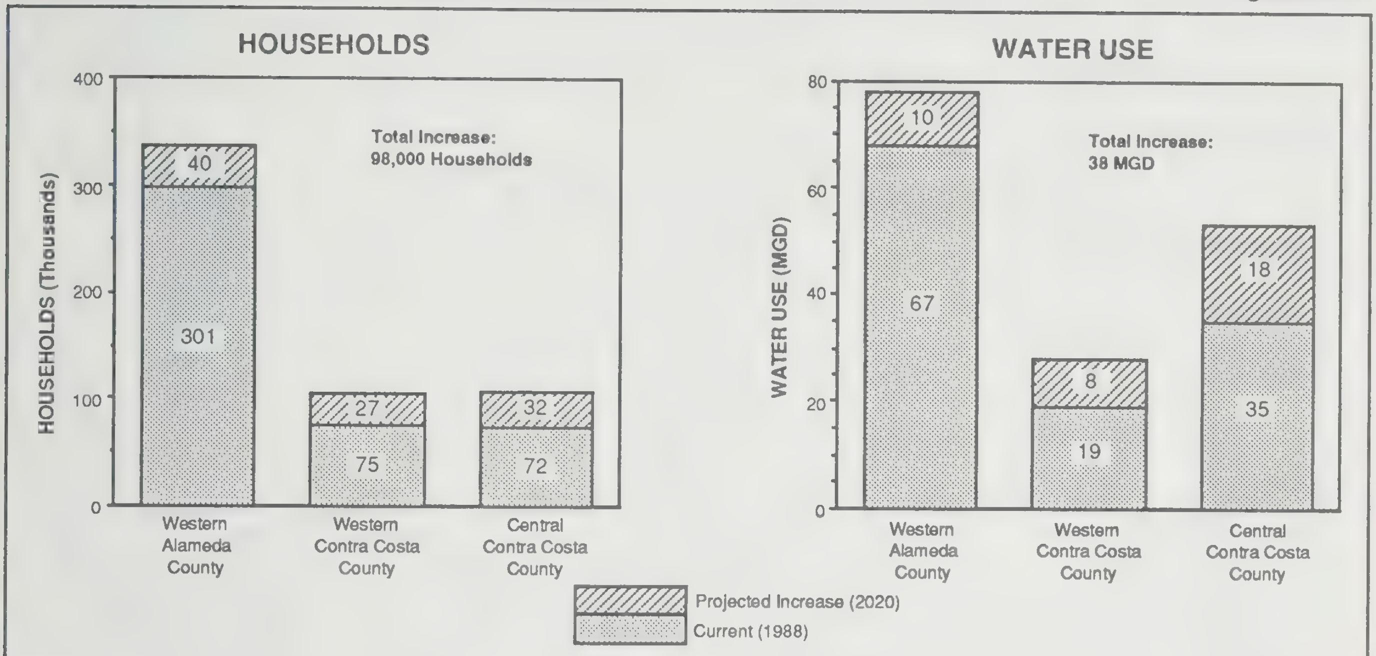
BASE CASE

Figure III-30 describes the estimated expenditures and savings for current water conservation measures including continued education programs, programs to advise customers, and audits for residential and commercial customers. The Base Case also includes provisions for increased technical guidance in the design and construction of landscaped areas. It is assumed that all new construction will comply with State water conservation regulations, but that the technology to be employed in saving water will be that which exists today.

Water savings shown in Figure III-30 are projected to occur as a result of continuing conservation activities at current levels through the year 2020. The savings indicated build up gradually over time and are not expected to be fully realized until 2020. Also, actual savings may differ from that projected. As the District gains more experience with these measures and is able

## Projected Increases 1988 — 2020

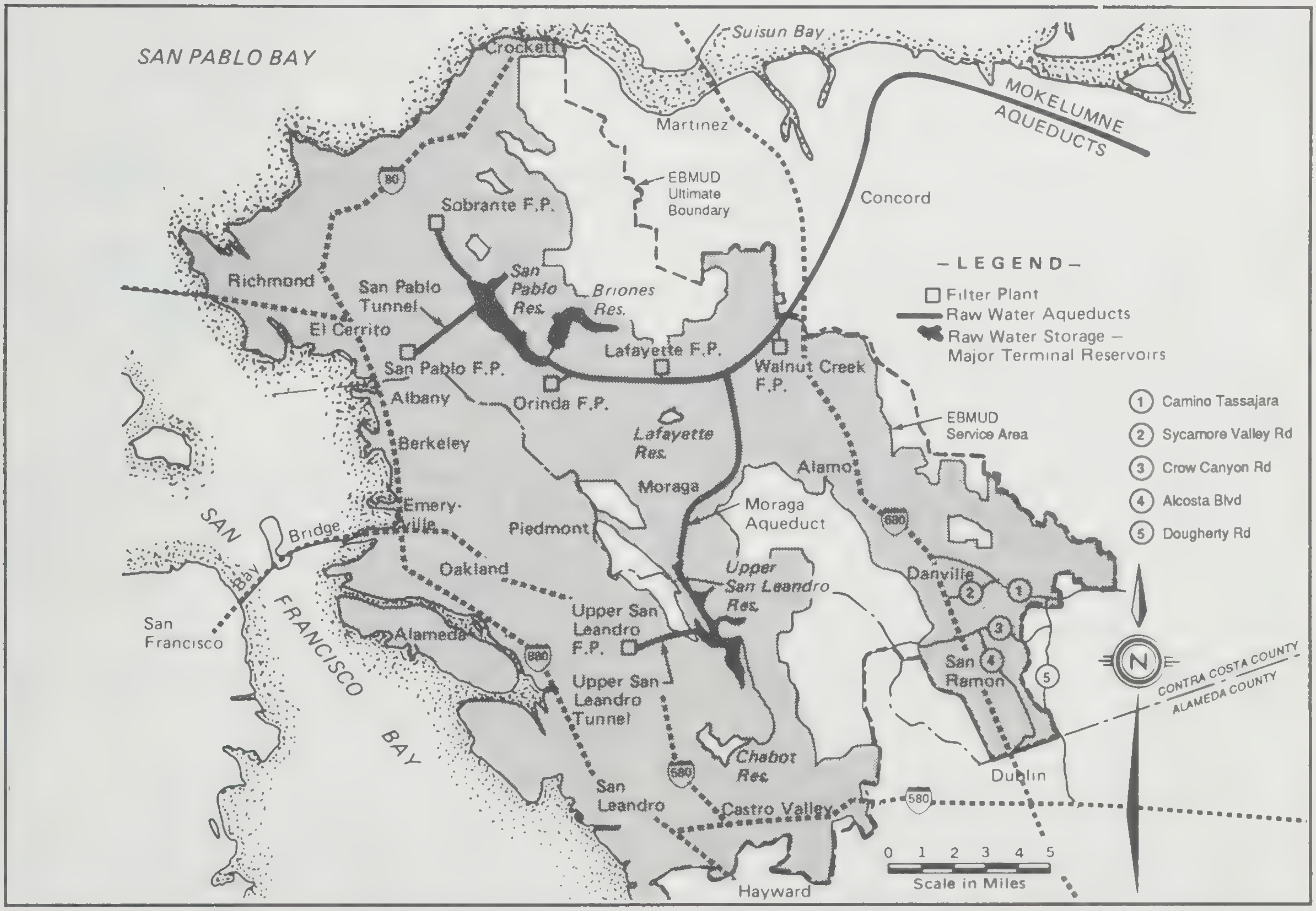
Figure III-26




Source: Association of Bay Area Governments, State Dept. of Finance, EBMUD Office of Planning

## Ultimate Boundary

Figure V-27A



## Water Demand and Requirements Projections (MGD)

Figure III-27B

| CATEGORY | 1986 | 1990 LOW | 1990 HIGH | 2020 LOW | 2020 HIGH |
|---|---|---|---|---|---|
| **Customer Use (Metered)** | | | | | |
| Residential — Single Family | 91 | 87 | 99 | 114 | 129 |
| — Multi-Family | 31 | 30 | 31 | 32 | 37 |
| Commercial & Institutional | 32 | 26 | 30 | 32 | 41 |
| Industrial — Oil Refineries | 15 | 18 | 21 | 16 | 23 |
| — Other | 15 | 14 | 15 | 17 | 23 |
| Park, Golf, and Cemetery | 12 | 9 | 10 | 11 | 13 |
| Miscellaneous | 2 | 2 | 2 | 2 | 3 |
| Subtotal* | 198 | 185 | 207 | 224 | 268 |
| **District Use** | 1 | 1 | 1 | 1 | 2 |
| **Unaccounted-for-water**** | 16 | 16 | 18 | 20 | 24 |
| Total Demand* | 215 | 203 | 227 | 247 | 294 |
| **Planning Projection** | | | | | |
| Reasonable level within the range with 10 MGD variance for weather and other conditions | | 225 | | 280 | |
| Projected Additional Savings | | | | | |
| — Water Conservation, Existing and Proposed Program | | -0.3 | | -6 | |
| — Water Reclamation, Proposed Program | | -0.2 | | -5 | |
| **WATER REQUIREMENT*** | | 225* | | 270* | |

*Totals may not equal sum of categories due to rounding.
**Difference between measured water delivered into the distribution system at the filter plants and the total of all customer billed quantities.

to collect data on water saved, the projected water savings and the measures themselves may change.

**Leak Detection and Pipeline Rehabilitation.** The District's leak detection and pipeline rehabilitation program is described in detail earlier in this chapter. Water saved as a result of the leak detection program ranges from 0.5 MGD to 1.5 MGD each year. The water saved is not cumulative since the leaks would be discovered within a year or two even without the leak detection program. Early detection and repair helps the District minimize unaccounted-for losses and maintain a tight water system.

The total direct cost of the leak detection and pipeline rehabilitation program is estimated to be:

| | |
|---|---|
| Leak Detection Program | $ 600,000/yr. |
| Repair of Pipeline Leaks and Breaks | 1,700,000 |
| Pipeline Replacement | 4,100,000 |
| Total | $6,400,000/yr. |

**Metering.** The EBMUD distribution system is 100 percent metered. Studies have indicated that metering results in an average water use reduction of 20 percent as compared to unmetered use. However, since the water use effect of metering is already included in the District's water use characteristics, no additional water savings are attributed to metering.

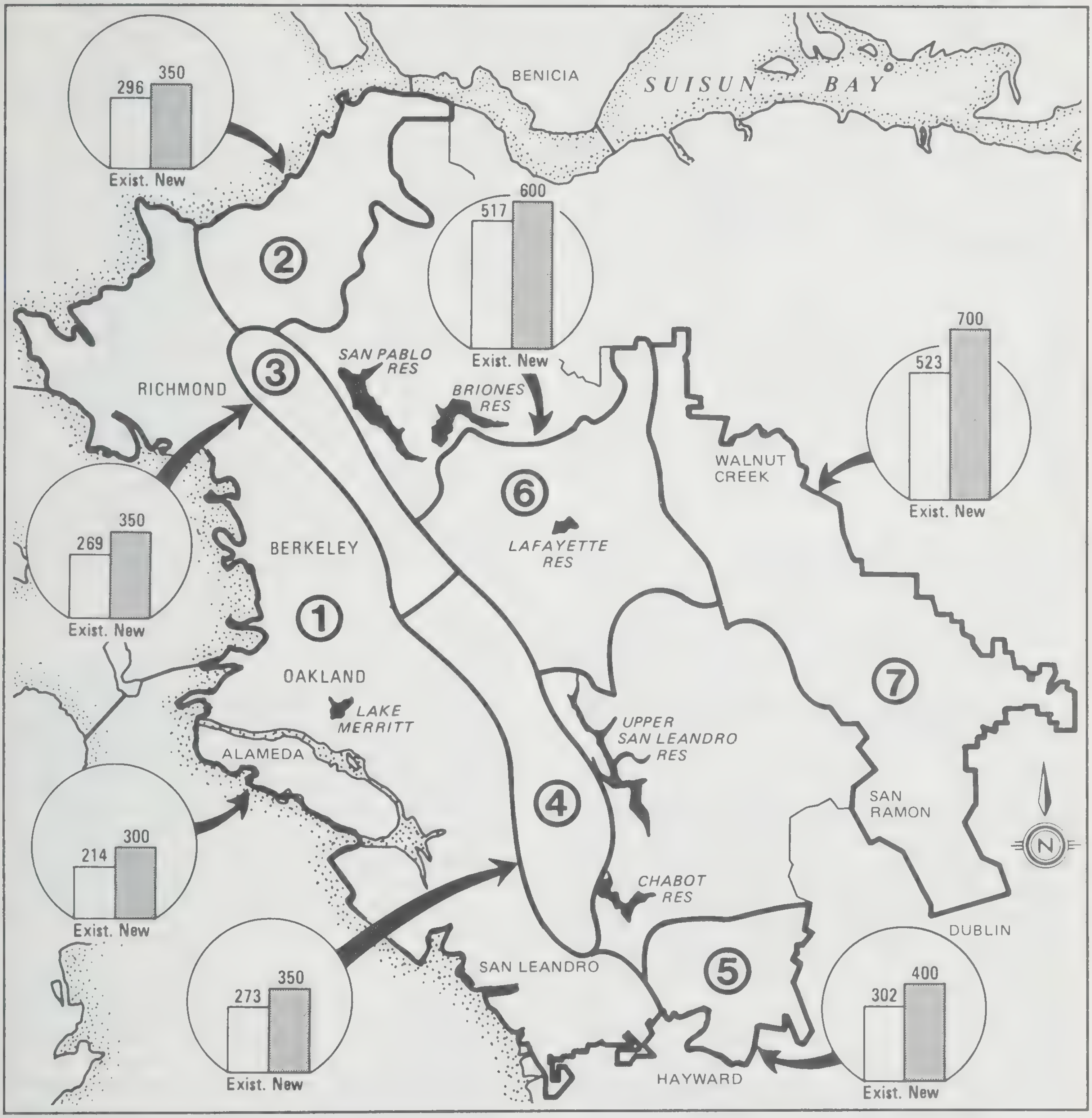
The District spends $400,000 annually purchasing and installing meters for new customers and $1,300,000 for inspecting, testing, and repairing existing meters to assure water use is measured accurately and revenues are collected fairly.

**Water Saving Device Distribution.** The District currently plans to distribute about 20,000 retrofit kits per year. The kits will include a low-flow showerhead, two toilet displacement bags, and dye tablets for finding toilet leaks. Approximately one-third of the kits will be distributed door-to-door in selected areas, with the remaining being available at District business offices. The primary focus of the device distribution will be single and multi-family residential customers.

Continuation of this program has the potential to save up to 1.9 MGD in 2020 based on the assumptions discussed above. Currently, the District is evaluating the rate of use and satisfaction with retrofit devices distributed to customers in the last year. Results of this evaluation may change some of the above assumptions.

## Single Family Residential Water Use by Region for Existing and New Customers (Gallons per Day per Household)

Figure III-28



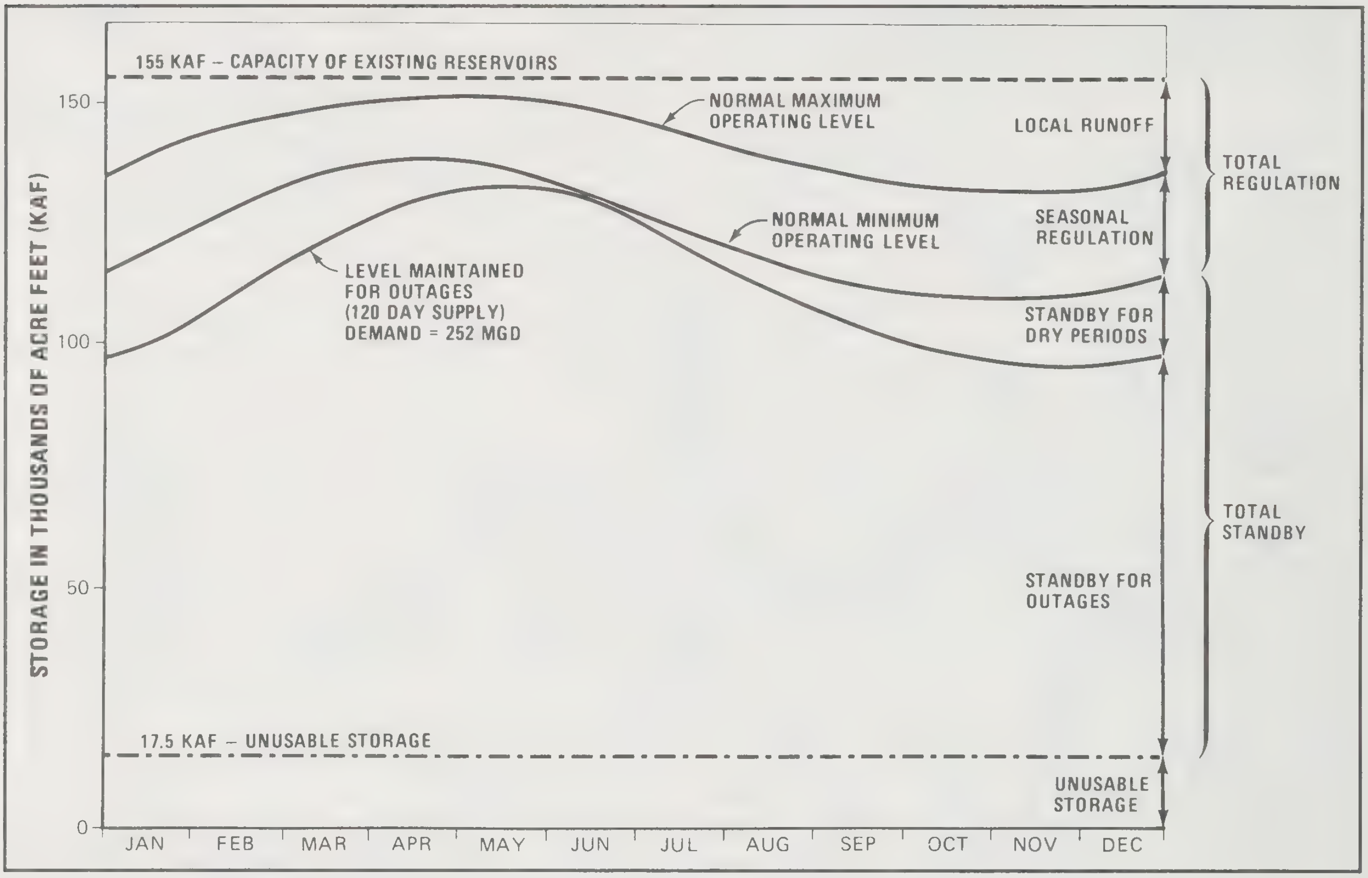

Installation of low-flow showerheads may also result in energy savings for customers due to reduced hot water heating. This savings is estimated to be \$24.80/year and \$19.00/year for single and multi-family residences, respectively.

**The distribution of retrofit kits will be increased during drought years. During the 1987-88 drought over 50,000 kits have been distributed. The retrofit kits provide a quick and simple means for customers to reduce inside water use during emergency conditions.**

**The District has also examined the potential water savings from ultra low flush toilets and ultra low flow showerheads installed in homes. The District's support of state-wide legislation in this regard is described later in this chapter. If such a measure is adopted then distribution of the retrofit kits may,**

## Limitations of Terminal Reservoirs at 252 MGD Demand

Figure III-29




**at some future time, be superseded by installation of permanent fixtures.**

**Water Audits.** The purpose of water audits is to examine water use practices, detect leaks, and make recommendations for improved efficiency. The District plans to conduct about 300 audits per year. Multi-family residential and commercial and institutional customers will be targeted for the audits because of their water use characteristics. Both inside and outside water use practices will be examined. The District will monitor the water use of customers following the audit to determine how much water is actually saved.

Because this program was just recently initiated, data are not available on how customers have responded to District recommendations or on what water savings have resulted from changing water use practices as a result of the audit. Therefore, projected water savings will not be certain until reliable data can be produced.

**Landscape Consultations.** In 1987, the District initiated a program offering low water using landscape advice and information to customers planning to either install new or alter existing landscaping. The primary focus of this program has been residential customers, including apartment complexes, home owner associations, condominiums, and single family residences.

Water savings for this program are very difficult to estimate since the customer attitude toward drought tolerant landscaping is unknown. The District plans to follow-up consultations by monitoring water use and conducting surveys with customers to determine customer attitudes and water savings. Even if the program should achieve only limited water savings, it is important in maintaining a public awareness of opportunities to save water through landscaping techniques.

**Landscape Water Use Efficiency in New Developments.** The District's "model" guidelines establishing criteria for landscapes in new developments are intended to increase outside water use efficiency by 25 percent in new developments in the service area.

Water savings estimates for this program assume that guidelines will be imposed on all new developments (except single family residences) and that outside water use in these new developments will be 25 percent more efficient. This results in potential water savings in 2020 of up to 1.1 MGD.

**Demonstration Gardens.** The purpose of the District's demonstration gardens program is to show

the public the attractiveness, low maintenance, and low water use of this type of landscaping.

Low water use landscapes have been demonstrated to reduce irrigation water use by up to 90 percent. However, no water savings for this measure are given since the purpose of the program is public awareness.

**Irrigation Upgrade Pilot Study.** In 1988, the District plans to conduct an irrigation upgrade pilot study, in cooperation with other public agencies, to determine irrigation efficiencies and analyze the potential benefits of an incentive or rebate program to encourage upgrading irrigation systems. The study will focus on the District's 100 largest irrigators, which comprise approximately 7.5 percent of outdoor use.

The cost of fully automating and controlling a large irrigation system ranges from $1,500 to $25,000 per acre depending on the condition of the existing system. Items which could be considered in an upgrade include: master irrigation controllers, moisture sensors, check valves, low volume sprinkler heads, precipitation and wind override devices, pressure reducing valves, and separate valving determined by plant needs.

There are no data currently available on how much water savings could be anticipated from irrigation system upgrades. The purpose of the pilot study is to determine whether irrigation upgrades are cost effective, estimate potential water savings, evaluate current water use practices of the District's 100 largest irrigators, and determine the feasibility of offering an incentive or rebate to customer for upgrading irrigation systems.

The District will conduct the pilot study in cooperation with the Department of Water Resources (DWR) and another local agency.

**Public Information and School Education.** Water conservation public information and education material available from the District is described earlier in this chapter. The information is intended to increase public awareness of the water use efficiency and inform customers of opportunities to save water.

The cost of this effort varies from year to year as new material is produced; however, the average annual cost of the District's public information campaign on water conservation is estimated to be $75,000 per year. No water savings are attributed to this effort although some water savings may result.

In summary, the Base Case conservation program should result in an additional water savings, above that already present in customer water use characteristics, of approximately 4.0 MGD by the year 2020. It should be noted that these savings are conjectural since it is impossible to measure the actual savings resulting from many of the measures. The total annual cost of the District's current water conservation program is estimated to be $260,000 per year. This does not include the cost of the leak detection, pipeline rehabilitation, and metering efforts since these functions would be performed regardless of their water saving benefits.

## ADDITIONAL WATER CONSERVATION MEASURES

In developing the Water Supply Management Program, the District has evaluated additional water conservation measures beyond those already being implemented. Because the District has water available in excess of its needs a majority of the time, the approach has been to select voluntary type measures that either have been shown to be successful or have potential for being successful.

While the methods and technology are available to reduce water use, a major problem is determining the most appropriate method for implementing water conservation measures. For example, the District's demonstration gardens have shown that outside water use can be trimmed by 90 percent. To achieve this savings, the customers must be willing to spend time and/or money to change their landscaping, know and understand the water needs of the plants, and actively control and monitor actual irrigation.

The District's role in promoting and encouraging water conservation, short of a critical situation such as a drought, has focused on educating customers, and providing information on and incentives to saving water. The District assists customers in achieving efficient use and allows customers to determine to what extent they will conserve.

Figure III-31 summarizes additional water conservation measures that have the potential for water savings and are considered reasonable, feasible, practical, and acceptable. In summary, the alternative water conservation program, which includes the Base Case plus the additional measures indicated in Figure III-29, is estimated to provide 6 MGD of water savings by 2020. The total annual cost of this alternative conservation program is estimated to be about $755,000 per year, an increase of $496,000 over the current Base Case program.

The following describes in further detail the proposed conservation measures listed in Figure III-31.

## Water Conservation Base Case

| MEASURE | TYPE OF USE AFFECTED | BENEFITS OF MEASURE |
|---|---|---|
| LEAK DETECTION AND PIPELINE REHABILITATION<br>• Leak detection crews survey approximately 300 miles per year<br>• Repair 600-800 leaks and breaks per year<br>• Replace approximately 7.5 miles of pipe per year due to poor condition | Distribution System Losses | • Minimize system losses (unaccounted-for water)<br>• Maintain integrity of distribution system |
| WATER METERING<br>• All customers metered<br>• All District Facilities metered<br>• Routine inspection, testing, and repairing of meters<br>• Past and present water use shown on customer bills | All Water Use | • Equitable collection of revenues<br>• Reduces overall water consumption<br>• Provides means for identifying leaks on customer's side of meter<br>• Reduces unaccounted-for losses due to inaccurate meter |
| WATER SAVING DEVICE DISTRIBUTION<br>• Distribute free retrofit kits to customers<br>• Kits include: low flow showerhead<br>toilet displacement bag<br>dye tablets<br>• Approximately 20,000 kits distributed per year with increased distribution during drought years | Residential Inside Use | • Devices have potential to save up to 9.8 gpcd (or 23.0 gpd/SFDU and 17.6 gpd/MFDU in 2020)<br>• Low flow showerhead also saves energy due to reduced hot water usage |
| WATER AUDITS<br>• Program initiated in 1987<br>• 100 water audits performed<br>• Anticipate 200 audits per year | MF Residential Commercial & Institutional Inside & Outside Use | • Recommend methods of improving water use efficiency<br>• Identify opportunities to save water<br>• Identify potential leaks |
| LANDSCAPE CONSULTATIONS<br>• Program initiated in 1987<br>• Approximately 50 landscape consultations<br>• Anticipate 100 consultations per year | Residential Outside Use | • Recommend plants and materials for reducing outside water use<br>• Review landscape plans and provide advice |
| LANDSCAPE WATER USE EFFICIENCY IN NEW DEVELOPMENTS<br>• EBMUD established model guidelines for cities and counties to adopt<br>• Contra Costa County and cities of Albany, Danville, El Cerrito, Piedmont and San Leandro have adopted modified guidelines<br>• Guidelines have been imposed on three annexations to the District | New Developments Outside Use | • Requires new developments to conform to specified guidelines for landscaped area<br>• Reduce outside water use by estimated 25% |
| DEMONSTRATION GARDENS<br>• Construct approximately two demonstration gardens per year in cooperation with other agencies | Outside Use | • Demonstrate the attractiveness, low maintenance and low water use of drought tolerant landscaping |
| IRRIGATION UPGRADE PILOT STUDY<br>• To be initiated in 1988 in cooperation with other agencies<br>• Conduct studies to determine:<br>- irrigation efficiencies<br>- potential benefits of upgrading irrigation systems<br>- potential effectiveness of an incentive/rebate program | Non-Residential Outside Use | • Develop data on potential water savings and cost effectiveness of upgrading irrigation systems<br>• Determine customer responsiveness to incentives or rebates to encourage water savings |
| PUBLIC INFORMATION AND SCHOOL EDUCATION<br>• Landscape Book and Brochure<br>• Landscape Video<br>• Exhibits<br>• Speakers Bureau<br>• Educational Software<br>• Water Conservation Activity Center | All Water Use | • Provide information on efficient water use<br>• Inform customers of conservation assistance available through other programs |

Figure III-30

| COSTS OF MEASURE | ESTIMATED ADDITIONAL WATER SAVINGS IN 2020 | CUSTOMER/COMMUNITY RESPONSE | COMMENTS |
|---|---|---|---|
| • Leak detection - $600,000 per year<br>• Pipeline repairs - $1,700,000 per year<br>• Pipeline replacements - $4,100,000 per year | • NO ADDITIONAL WATER SAVINGS<br>• Approximately 0.5 to 1.5 MGD saved each year; this savings is not cumulative<br>• Continuation of program will maintain a low rate of unaccounted-for water losses | • Customer reported leaks are repaired promptly<br>• District notifies customers of customer side leaks | • Continuous effort required to maintain long term integrity of distribution system |
| • $400,000 spent per year on new water meters<br>• $1,300,000 spent per year on inspecting and repairing meters | • NO ADDITIONAL WATER SAVINGS<br>• Actual quantity of water saved is unknown<br>• Nation-wide studies indicate 20% water savings when water is metered | • No adverse customer response to metering<br>• Assists customer in locating leaks | • Standard District practice since 1923 |
| • No cost to customers<br>• Kits cost District $3.00 each, or approximately $60,000 per year<br>• Total program cost is approximately $72,000 per year | • POTENTIAL SAVINGS: Up to 1.9 MGD<br>• Water savings from kits already distributed is unknown | • Customer satisfaction with kits is unknown<br>• Actual installation rate and life of kits is unknown<br>• Ten-year life is assumed | • Requires continuous effort by District to maintain level of usage<br>• Water saving potential significantly reduced when installed in homes built after 1978 |
| • District cost of program estimated to be $40,000 per year, primarily staff time<br>• Modifications made by customers may have some cost; this is assumed to be offset by cost savings | • POTENTIAL SAVINGS: Up to0.9 MGD<br>• Savings from program to date is unknown | • Customer response to District recommendations is unknown | • District is monitoring the response to the program; no conclusions can be drawn at this time |
| • Estimated total cost to District is $17,000 per year<br>• High customer costs due to relandscaping; assume decision to relandscape and decision to use low water using materials is separate decision | • POTENTIAL SAVINGS: Up to 0.1 MGD<br>• Water savings from program is uncertain | • Customer response to program is unknown | • District is monitoring the response to the program; no conclusions can be drawn at this time |
| • Unknown administrative costs to be borne by cities and counties adopting guidelines<br>• District cost estimated to be $30,000 per year | • POTENTIAL SAVINGS: Up to1.1 MGD<br>• Actual water savings is unknown; guidelines have just been implemented | • Guidelines not in effect long enough to determine response | • Other cities are considering guidelines and may adopt them in the future |
| • Construction of two gardens per year estimated to cost $25,000 per year<br>• Sponsoring agencies would be responsible for operation and maintenance of gardens | • NO ADDITIONAL WATER SAVINGS<br>• Gardens are for demonstration purposes; no water savings are attributed<br>• Gardens have demonstrated a potential for 90% water savings in outside use | • Public agencies are supportive of gardens | |
| • Estimated cost to administer a pilot program is $5,000<br>• Assumes DWR would contribute the cost of upgrading an existing landscaped area<br>• Cost to fully automate a large irrigation system ranges from $1,500 to $25,000/acre | • NO ADDITIONAL WATER SAVINGS<br>• No water savings are attributed to the pilot program | • Customer response to incentive/rebate programs not known | |
| • Total District cost is estimated to be $75,000 per year | • NO ADDITIONAL WATER SAVINGS<br>• Water savings from public information is not quantifiable | • The District has received positive response from past public information and education efforts | • Public information and education is a necessary element of any balanced conservation program |

## Additional Water Conservation Measures

| MEASURE | TYPE OF USE AFFECTED | ESTIMATED BENEFITS OF MEASURE |
|---|---|---|
| WATER SAVING FIXTURES IN NEW CONSTRUCTION<br>• Support State legislation requiring ultra low water using fixtures and appliances in all new construction | Inside Use | • Potential to save 10.9 gpcd in new residential water use<br>• Low flow showerheads and appliances save energy due to reduced hot water usage<br>• Additional savings from non-residential customers |
| WATER AUDITS FOR INDUSTRIAL PROCESSES<br>• Expand water audit program to include industrial processes<br>• Anticipate 100 industrial audits per year<br>• Emphasis would be on installing low water use equipment for sanitary, cooling and process water<br>• Audits would include water, wastewater and energy (as appropriate) | Industrial<br>Inside Use | • Industrial customers tend to use large quantities of water; therefore a relatively small number of audits could result in high water savings |
| LANDSCAPE CONSULTATIONS<br>• Expand current Landscape Consultation Program to non-residential customers<br>• Anticipate 200 consultations per year<br>• Landscape consultations would be similar to water audits but would focus on outside water use | Non-Residential<br>Outside Use | • Target larger landscape areas where potential water savings would be greater<br>• Provide information on plants and materials, irrigation systems, etc.<br>• Review landscape plans and make recommendations |
| IRRIGATION MANAGEMENT<br>• Encourage irrigation of large landscaped areas to be scheduled using evapotranspiration data<br>• District would conduct training seminars for landscape maintenance personnel | Non-Residential<br>Outside Use | • Increase irrigation efficiency without changing landscapes |
| ADDITIONAL DEMONSTRATION GARDENS<br>• Develop 4 (rather than 2) demonstration gardens in public areas each year<br>• Work with local public agencies to encourage use of low water landscaping in public areas | Outside Use | • Demonstrate attractiveness and low maintenance of low water using landscapes |
| LANDSCAPE REBATE<br>• Pilot program to encourage use of low water using landscapes by existing customers<br>• Offer rebates for customers who meet District criteria | Existing Customers<br>Outside Use | • Encourage customers to choose low water using plants when relandscaping<br>• Reduce outside water use |
| RESIDENTIAL WELL WATER USE<br>• Install, test, and maintain backflow prevention devices at water meters for residential customers with wells | Residential<br>Outside Use | • Avoid loss of supply estimated at 0.5 MGD |

Figure III-31

| ESTIMATED COSTS OF MEASURE | ESTIMATED ADDITIONAL WATER SAVINGS IN 2020 | CUSTOMER/COMMUNITY RESPONSE | COMMENTS |
|---|---|---|---|
| • Little or no additional cost to customers<br>• Economies of scale may be realized with state-wide adoption | • POTENTIAL SAVINGS: Up to 2.1 MGD<br>• Actual savings would depend on the legislation that is passed | • Design/performance improvements may make fixtures and appliances more acceptable<br>• Requires state-wide support | • Following adoption of state legislation for new construction, District may consider measures for existing customers |
| • District costs for this program are estimated to be $75,000 per year, primarily staff time<br>• Customers may be faced with costs to modify processes. However, these costs are assumed to be offset by cost savings | • POTENTIAL SAVINGS: Up to 1.1 MGD<br>• Water savings resulting from industrial water audits would be estimated on an individual basis | • Industrial customers have demonstrated a willingness to reduce water use when overall cost savings can be achieved | • Long payback periods for process modifications may affect customer response |
| • District cost for this program is estimated to be $38,000 per year, or an increase of $21,000 per year over the current program<br>• Customers would have landscaping costs, but these are assumed not to increase due to use of low water use plants and materials | • POTENTIAL SAVINGS: Up to 0.2 MGD<br>• This is the incremental savings from expanding the program; total from landscape consultations would be 0.3 MGD | • Customer response to this program is unknown | |
| • District costs estimated to be $5,000 per year to conduct training seminars<br>• Customers would incur minor costs in training landscape maintenance personnel | • POTENTIAL SAVINGS: Up to 0.4 MGD | • Customer response to this program is unknown | • District maintains a weather station which can provide evapotranspiration data to landscape personnel |
| • Construction of four gardens per year estimated to cost an additional $25,000 per year<br>• Sponsoring agencies would be responsible for operation and maintenance costs of gardens | • NO ADDITIONAL WATER SAVINGS<br>• Gardens are for demonstration purposes; no water savings are attributed | • Public agencies have been supportive of gardens | |
| • Pilot program would last for 2 to 3 years<br>• District costs estimated to be $120,000 per year | • NO ADDITIONAL WATER SAVINGS<br>• No water savings are attributed to the pilot program | • Pilot program would test public responsiveness to incentives to encourage low water landscapes | • Program assumes customers have already decided to modify existing landscapes |
| • District costs for this program are estimated to be $250,000/year for the first five years and $155,000/year thereafter | • NO ADDITIONAL WATER SAVINGS<br>• Additional water savings resulting from extra new wells being drilled is uncertain | • Customer response is unknown but probably supportive | • Installation and annual testing of backflow prevention devices is mandated by state regulations |

Water Saving Fixtures in New Construction

Since 1978, State law has required the installation of low water using fixtures, including showerheads with a maximum of 2.75 gpm and toilets with a maximum of 3.5 gal/flush, in all new construction. Also, any new showerheads or toilets purchased within the State, at hardware or home improvement stores, must conform to these standards.

Advancing technology is leading toward the development of high quality ultra low water using toilets, showerheads, and water using appliances. As the design and performance of these fixtures improve they may become acceptable to the general population. Additional water savings could then be achieved through new State legislation which would require the installation of the ultra low water using fixtures in all new construction. The District could support or co-sponsor such legislation in an effort to conserve more water state-wide.

Possible State legislation could include requirements for 2.0 gpm showerheads, 1.5 gal/flush toilets, and low water using appliances in all new construction. If adopted on a state-wide basis, economies of scale may result in lower cost and greater supply of the ultra low water using fixtures and appliances. No additional cost, over current standard fixtures, would be expected.

If this measure were implemented as described above, the potential water savings within the EBMUD service area is projected to be 2.1 MGD by the year 2020.

Following the implementation of State mandated requirements for new construction, the District could consider requiring the replacement of existing toilets and showerheads, in existing residences, with the ultra low water using models. This could either be a requirement at the time of resale and/or an incentive (rebate) could be provided to encourage customers to replace these fixtures. A requirement to have toilets and showerheads replaced at the time residential property is sold would have the potential to save up to 12.8 MGD by the year 2020.

Unlike a requirement for new construction, a replacement measure would have a considerable cost. At a cost of $300-$400 to replace a toilet and showerhead, EBMUD customers could face an average cost of $9.6-$12.8 million per year if required to replace toilets when residential property is sold.

**Water Audits of Industrial Processes.** The District's water audit program could be expanded to include industrial customers. Emphasis would be to encourage owners to install low water use equipment for sanitary, cooling, and process use. The scope of the audit would include water, wastewater, and energy audits (as appropriate) to increase customer response. Customer cost for plant modifications would be determined on a case-by-case basis. However, it is reasonable to assume customers would be reluctant to make changes unless a long-term net benefit could be demonstrated.

**Landscape Consultations.** To date, the District has provided landscape advice when specific customer inquiries have been made. The District could increase its landscape consultation efforts by actively advertising the service through mailings and personal contact. The landscape consultations could also be expanded to include commercial and institutional customers in addition to residential customers.

**Landscape Irrigation Management.** The purpose of this measure is to increase irrigation efficiency through improved scheduling using existing irrigation systems. The irrigation system upgrade pilot program, described earlier in this section, will evaluate the potential for water savings by upgrading irrigation systems. This measure would target large irrigation water users that could benefit from more efficient management of irrigation in landscaped areas.

The District would make an effort to have irrigation on all large lawn areas, such as golf courses and parks, scheduled using real-time climate data. This would be accomplished by holding training classes for professional landscape maintenance personnel on how to schedule irrigation based on average evapotranspiration (ET) values, encouraging upgrades of irrigation systems, and offering free audits for larger lawn areas. The District would maintain its weather station, established in 1987, to provide real time ET data and would assist in developing cooperative pilot and research projects.

The major component of this measure would be to educate customers in how to use real time evapotranspiration data for managing their irrigation. Customers would incur minor costs to educate personnel. Other expenses may occur if irrigation systems are modified or improved. However, because this would be a voluntary measure, it is assumed that any customer costs would be negligible and would be recovered through water saving benefits.

The willingness of landscape maintenance personnel to incorporate more efficient techniques is not known. However, if 20 percent of the parks and golf courses

and 10 percent of other commercial and institutional customers reduce outside water use by 15 percent through improved irrigation management, an estimated 0.4 MGD could be saved by 2020.

**Additional Demonstration Gardens.** Currently, EBMUD is working with other public agencies to develop about two new demonstration gardens each year (see discussion on past and present water conservation activities). The District could increase its effort in assisting other agencies to build low water using landscape gardens in public areas.

The increased cost for developing more demonstration gardens would depend, partially, on the willingness of other public agencies to support the gardens. The purpose of the gardens is to demonstrate the attractiveness and low water use of drought tolerant landscapes. Therefore, no water savings are attributed to the demonstration gardens.

**Landscape Rebate - Pilot Program.** The concept of providing incentives, in terms of District rebates to existing users, must be tested to determine effectiveness. Considering the fact that the average new home in the District is in the $200,000 price range and that the average monthly water bill even in the higher water using areas may be in the range of only $20 a month, a rebate may have to be quite significant to induce modifications resulting in significant water savings.

As part of a pioneering effort to encourage low water landscaping, the District could implement a pilot program to test the effectiveness of offering rebates to customers who install low water landscapes that meet District criteria. The program would be targeted to customers who were already contemplating re-landscaping their yards.

The District could test the program over a 2 to 3 year period to determine the level of customer interest in a cash incentive. It may be that a higher incentive will be necessary to encourage customers to use low water using plants and materials as opposed to more traditional landscapes. The details of a pilot program need to be developed.

Because this would be a 2 to 3 year program to test public response to a rebate as a method of encouraging water efficient landscapes, no water savings are attributed to this measure.

Residential Wellwater Use Program

**There are approximately 2,700 residential wells in the District's service area. In 1987 state regulations were revised to require that residences which utilize wellwater have a backflow prevention device installed at the water meter and tested annually to protect the drinking water system from backflow of wellwater. Approximately 1,700 of the wells are in the District's records and most are not equipped with backflow prevention devices. The remaining 1,000 wells are not yet in the District's records, and most of these residences also are not equipped with backflow prevention devices. Approximately 300 permits for new wells were issued by the two counties between July 1987 and July 1988. This is 2 or 3 times the normal rate, due to the drought. If the District were to require customers with wells to install, maintain, and annually test the devices at their expense, it is estimated that about half of them, or 1,350 well users, would abandon the use of existing wells. Similarly, the number of new wells constructed would be reduced. In order to avoid this loss of supply and comply with state regulations, the District could install, test and maintain the devices at no cost to the well owner.**

## OTHER MEASURES CONSIDERED

The Water Supply Management Program includes implementable alternatives. EBMUD and other advocates of water conservation, through the Urban Water Management Plan and other activities, have studied most, if not all, conceivable water conservation measures. Many of these measures are either theoretical, difficult to quantify, or can be implemented only under unique limited circumstances. Theoretical measures that have been considered in the conservation analysis are summarized in Figure III-32 and described in more detail in Appendix F.

One measure considered would require all homeowners to replace existing toilets with ultra low flush (1.5 gal/flush) toilets at the time the property is sold. The potential water savings from this requirement may be significant; however, consideration must also be given to customers who are required to spend several hundred dollars to purchase and install new toilets. While this measure has just been implemented only in Monterey County, that area is experiencing a severe long-term water shortage and has different needs to be met.

## ASSESSMENT OF WATER CONSERVATION

This chapter addresses the goal of assuring the District has sufficient water supplies to meet the reasonable demands of its customers. The purpose of the District's conservation program has been to assure that customers' demands are reasonable and avoid waste.

## Theoretical Measures* Figure III-32

| MEASURE | WATER SAVINGS** (MGD) |
|---|---|
| Ultra Low-Flow Toilets and Showers in New Construction | 2.1 |
| Mandatory Toilet Replacement for Residential Customers | 12.8 |
| Mandatory Toilet Replacement for Non-Residential Customers | 0.5 |
| Landscape Rebate | 1.3 |
| Water Efficient Technology | 0.7 |
| Potential Total Additional Savings | 17.4 |

*These measures may have the potential for additional water savings but they are costly, have unproven records and/or impose mandatory restrictions.

**Water savings may not be additive due to overlap of measures.

In nine years out of ten, the District's water supplies are more than sufficient to meet customers' demands. However, climatic patterns in California occasionally result in dry periods in which the availability of supply may be insufficient to meet demands. This occurred during the 1976-77 drought and is occurring again in 1987-88. EBMUD recognizes that it is not reasonable, nor feasible, to assure that 100 percent of customers' water needs are met 100 percent of the time. When adopting its Water Supply Availability policy in 1985, the District established criteria in which, during infrequent dry periods, insufficient water supplies would be met by cutbacks in customer demand. With the policy, the District linked water availability to both long-term conservation and short-term demand reduction measures. One effect of a long-term conservation program is to reduce the District's ability to respond to a drought with short-term demand reduction measures.

It has been documented that customers will respond to water use reduction programs only in emergencies and in rare periods of water deficiency. This was illustrated in 1977 and again in 1988. Since water supplies are more than adequate in most years and the cost factors associated with increasing those supplies are within the level of affordability, it would seem that the most reasonable approach would be to steadily improve water use efficiency as measures are demonstrated to be both acceptable and cost-effective and at the same time expect the District's water users to make drastic cuts during times of shortage. This approach has been advocated in current District planning.

## KEY FACTORS

In reviewing results from the analysis of the base conservation program, the alternative program, and District response to the shortages of 1976-77 and 1987-88, the following key factors should be considered:

- Water conservation programs are not directly comparable to a new water storage reservoir or a connection to a new source of supply, since conservation programs take years to implement, have unproven and uncertain success, and are difficult to quantify.
- The measures that appear feasible have been included in the proposed conservation alternative, which could be implemented individually or in connection with other water supply alternatives described in this Chapter.
- It is uncertain that measures that have not been demonstrated in the EBMUD or on a large scale in other locations are currently feasible and assessable alternatives, i.e., the acceptance of requiring a 1.5-gallon-per-flush toilets to be retrofitted in individual homes is not readily determinable, nor is it to determine what health authorities would require to allow the installation of a dual distribution system in apartments, hotels, or even individual houses.
- In assessing how much water might be saved by these measures, it is difficult to predict the quantity since accurate data, except on small scale demonstration projects for specific appliances like low-flow showerheads, are not available.
- There are social and economic impacts of various water conservation measures. For instance, many District residents of multi-family and single family homes, as well as users of institutions such as the University of California, enjoy the effects of large areas of greenery. These benefits, which are related to the way people view the urban landscape, are difficult to quantify. Clearly considerable water savings can be achieved without affecting these benefits, but measures, such as prohibition of lawns or other water-intensive landscaping, which some believe may substitute water conservation for major water supply development, would have the effect of changing the appearance of the urban landscape.

- The availability of adequate supplies of fresh water is a key factor in maintaining a strong existing economy, as well as development and redevelopment of a region. The development and redevelopment of the East Bay depends upon an adequate water supply that is perceived to be adequate. If the District undertakes a significant series of water conservation measures that are more rigorous than those employed in the United States generally or in Northern or Southern California in particular, this area would be perceived as having a long-term water deficiency.

- There appears to be a water rate effect of water supply shortage. Perhaps the most water-short area in the Bay Area has been Marin County. It is not coincidental that the Marin Municipal Water District's water rates are almost double the average of the Bay Area and significantly higher than EBMUD's rates. This appears to be due to an intentional policy to delay the construction of new water supply facilities and when such facilities are constructed to size them relatively small compared to the demand. Water rates to the average user are kept low by the construction of large facilities that ultimately have low unit costs. This approach has been the basis of the District's present economical rate structure.

This chapter has attempted to describe the District's existing water conservation programs, outline feasible improvements to that program as an alternative, and describe other measures which are not deemed to be feasible at this time, particularly those listed in Appendix F. Summarizing the status of water conservation and the conclusions of this chapter:

- EBMUD's total demand is about the same now as it was in 1975. Although the residential demand has increased, industrial demand has been sharply reduced.

- This increased efficiency means that the 1977 reduction level of 39 percent could not be achieved without significantly greater hardship and that if the shortage were to occur today, the same hardship would occur at the 35 percent level of savings and this level is likely to reduce to 31 percent by the year 2020.

- In addition to programs currently underway, the alternative water conservation program could succeed in achieving additional water savings, approximately 2 MGD by the year 2020.

- The District should support State legislation requiring the installation of ultra low flush toilets, ultra low flow showerheads, and other low water using appliances in all new construction.

- The District should undertake a series of pilot or demonstration projects to determine the feasibility of some of the measures that are identified in Appendix F.

- Even if these measures prove feasible, they do not provide for the range of needs which include security and storage against deficiency, either in terms of quantity or reliability.

EBMUD's Urban Water Management Plan, the legislation that it sponsored requiring such plans, and expenditure of over $755,000 per year to achieve water-use efficiency will give the District a program that is in comparative terms more aggressive than all but a few small utilities that have had extreme water shortages. In order to continue and to expand the District's water conservation efforts, the Base Case program plus the additional measures described in this section are included in all of the major supply alternatives identified in this chapter.

### Water Reclamation Projects

Most of the reclamation projects which the District found to be economically feasible have had several features in common: a large non-potable water demand, close proximity to a wastewater source, and minimal treatment requirements. This has resulted in the implementation of a reclamation program which currently saves nearly 5 MGD per year of potable water. Projects that may replace another 5 MGD of freshwater supplies are being evaluated. These projects are described below and summarized in Figure III-33.

Reclaimed water prices have been established for the Richmond Golf Course and the proposed Galbraith Golf Course project based primarily on recovery of District costs. This allowed the price to be significantly lower than the price of potable water and provided an incentive to the user to switch to reclaimed water. Due to the higher water quality requirements and subsequent treatment costs, the District's cost to implement the proposed Chevron project will be much greater. The proposed Chevron, and Galbraith Golf Course projects are described below.

#### ALAMEDA GOLF COURSES

In January 1987, a Facilities Plan for the Galbraith Golf Course Project was completed. This plan identified the project requirements and evaluated alternatives to reclaim up to 0.15 MGD (162 acre-feet/year) of secondary effluent from the San Leandro Water Pollution Control Plant (SLWPCP) for

## Potential Reclamation Projects

Figure III-33

| PROJECT | DESCRIPTION | STATUS | ANNUAL WATER SAVINGS (MGD) |
|---|---|---|---|
| Alameda Golf Courses | Expansion of present Galbraith Golf Course Project. Reclaimed wastewater from the San Leandro Treatment Plant. | Galbraith Project to be completed | 0.5 |
| Chevron USA Oil Refinery Cooling | Reclaimed wastewater from West Contra Costa Sanitary District or the Richmond Municipal Sewer District for reuse in Chevron's recirculating cooling tower. | Pilot study complete; startup date is 1991 | 4.7 |
| San Ramon Valley | Reclaimed wastewater from the Dublin San Ramon Services District for irrigation of golf courses, parks, playgrounds and schoolgrounds in the San Ramon Valley. | Planning Study | 1.4 |

irrigation of 110 acres. **The estimated construction cost of the project is $428,000. Approximately 25 percent will be funded by a low interest State loan.**

**The Galbraith Project will be saving 0.15 MGD for the remainder of this year.**

The Galbraith Golf Course project takes advantage of the relatively low cost of treatment and delivery facilities required for landscape irrigation. The SLWPCP is located adjacent to the golf course and treatment consists of chlorination to meet the coliform standard and dechlorination to remove traces of chlorine which may be harmful to turf grasses.

The District signed an agreement to finance the construction of chemical addition, pumping, piping, and storage facilities to deliver treated reclaimed water to the irrigation piping system. The golf course will be required to pay the up-front costs to adapt to the use of reclaimed water. These costs include piping modifications necessary to separate the potable water systems from the irrigation systems and the posting of signs and printing of scorecards to inform golfers of reclaimed water use.

**EBMUD is pursuing the expansion of the Galbraith Project to include the two Alameda Golf Courses. This project has the potential to use 0.5 MGD of reclaimed water.**

### CHEVRON OIL REFINERY

The Chevron oil refinery has been identified as the largest single potential user of reclaimed water in the District's service area. The potable water demand which could be replaced by reclaimed water is 4.7 MGD (5261 acre-feet/year), an amount representing the water use of approximately 20,000 average households in the Richmond area. This large demand, and the fact that the refinery is located within three miles of two sources of wastewater, contribute to the economic feasibility of this project.

The basic project features are:

- A project costing a total of $14.6 million ($12.0 million to be spent by EBMUD and $2.6 million to be spent by Chevron) can result in the replacement of 4.7 MGD of potable water with 5.4 MGD of reclaimed water.
- The reclaimed water will have lower quality, cannot be recycled as many times, and will require Chevron to incur higher refinery operating costs.
- The financing program would provide for the sale of reclaimed wastewater to Chevron at a 30 percent reduction from the retail water rate due to the need to purchase more reclaimed water to replace potable water and the extra capital and operating costs to the refinery to use reclaimed water.

The major difference between this project and the golf course irrigation projects is the more stringent water quality requirements. In order to allow reclaimed water to be used in recirculating cooling towers, it is necessary to reduce the concentration of certain contaminants which cause scaling, corrosion, and fouling of heat exchangers. This can be accomplished by the addition of chemicals in advanced wastewater treatment (AWT) processes. AWT processes include the addition of lime and soda ash to the water for softening or the reduction of calcium and phosphates which contribute to scaling. Although relatively expensive, AWT would bring the recycle rates for the cooling towers close to the rates provided by using potable water.

In addition to the cost of AWT, the use of reclaimed water would require Chevron to change to a more expensive type of cooling water treatment program to control the chemical stability of the water recirculated in the cooling towers. The use of this treatment program is well established at many other facilities; however, because Chevron has limited experience with it, the start-up period would require extra time and attention by maintenance and operation personnel. Other costs to Chevron would be for new pipelines, chemical metering equipment, and water quality monitoring instrumentation.

## SAN RAMON VALLEY

Another area where the District may have the opportunity to implement reclamation is in newly annexed areas. In the San Ramon Valley, there are areas which are being developed that could be the first at the District to have a dual water system (separate potable and reclaimed water pipelines). Reclaimed water could be used for irrigation of community landscaped areas. The cost of such facilities could be recovered from System Capacity Charges in much the same manner as are the costs of potable water facilities. Preliminary estimates indicate that the cost of these facilities would be high.

In August 1983, EBMUD, Dublin San Ramon Services District (DSRSD), and Alameda County jointly sponsored a study to investigate the potential for wastewater reclamation in the San Ramon Valley. The market survey identified 18 potential irrigation sites totaling 850 acres, including golf courses, greenbelts, parks, and schools. The recommended project focused on eight irrigation sites, totaling 488 acres. Parks and schools were eliminated because a higher level of treatment is required at a subsequently higher cost. This project has the potential to reduce the average annual demand for potable water by 1.4 MGD (1631 acre-feet/year).

The initial evaluation of the economic feasibility of this project showed that it was linked to the selection of the project by the local wastewater management agency disposing of highly treated wastewater to local creeks. This was because, if a reclamation project was selected, the Tri-Valley Wastewater Authority (TWA) would be responsible for the majority of the treatment and delivery costs required for reclamation. The District's costs would be limited to the lateral pipelines and pumping plants to serve the individual users.

Although it has become apparent that TWA will be proceeding with another disposal alternative and the project costs have increased to about $1000 per acre-foot, the project may still be considered if additional users can be found. However, the 1.4 MGD potential reclaimed water use for this project has not been included in projected additional reclaimed water use of 5 MGD used in this report.

### Water Banking (Additional Terminal Storage)

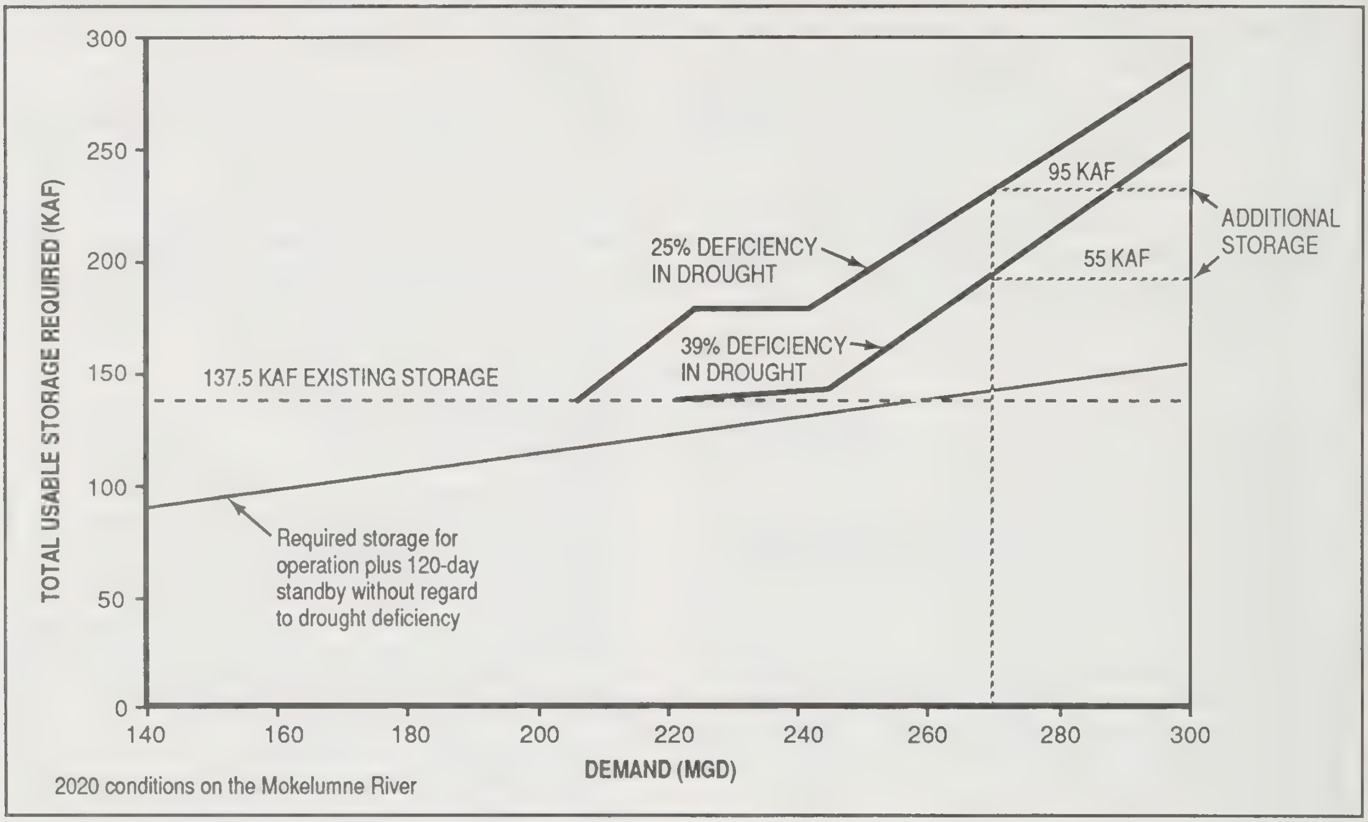
This section examines how additional terminal storage would help meet dry year shortages. However, it is important to note that additional terminal storage could also help meet the need for security against outages. The benefits of additional storage to the security of the water supply system are discussed in Chapter II.

EBMUD's water supply of 325 MGD from the Mokelumne River is adequate in most years to meet the current demand of about 220 MGD and the projected demand of 270 MGD in 2020. However, during drought periods like 1976-77 the supply is less than normal demand, in which case storage on the Mokelumne River and in the local service area is used to make up the difference together with planned water use restrictions. The existing water supply system can accommodate a percentage reduction in demand like that experienced in 1977 (39 percent) only until demand reaches about 240 MGD around the year 2000. A less severe level of rationing, such as a 25 percent reduction, cannot be accommodated at current demand with the existing system. Additional terminal storage would provide the supply necessary to accommodate the projected demand of 270 MGD in year 2020 and limit the level of rationing to 25 percent. The amount of storage needed depends on the level of normal demand and the planned restrictions on water use, as shown in Figure III-34.

As in the case of many other California Central Valley rivers, offstream storage which "banks" wet season flows can provide for enhanced flows in the lower Mokelumne River to meet downstream obligations to prior water right holders and fish flows that are prescribed in the District's water rights permits and numerous agreements with other Mokelumne interests, including the California Department of Fish and Game. The Department of Fish and Game and fishermen's organizations have complained that these commitments are being violated; the Department is conducting a comprehensive fishery study of the lower Mokelumne River, which is likely to result in recommendations for modified releases from Camanche. While EBMUD's obligation to deliver high quality drinking water is its first priority, the District is well aware of its other obligations on the river. The District uses these required releases to generate hydroelectric power. The greater the amount of storage within the District's system, the greater the flexibility that the

## Terminal Storage Needed to Meet Water Demand During Drought

Figure III-34




District will have to conduct its operations on the Mokelumne for the benefit of instream uses, such as fish enhancement.

Historically, the District has released an annual average of 95,000 acre-feet into the Mokelumne River to meet its downstream obligations to Woodbridge Irrigation District. This has provided significant flows for fish above the District's obligation. It also benefits groundwater pumpers whose wells are recharged with the excess flows in the river.

### Interties

As discussed in detail in Chapter II, the amount of supply available from interties would be limited and uncertain. No utility has a significant long-term surplus that EBMUD can depend on for the required water quantity and outage time. In addition, water rights and environmental issues associated with any change in source or place of use could be significant. Any interties with Hetch Hetchy system might help in the event of a Mokelumne supply outage, if the water were available; but this is an uncertainty. If water were available, a major intertie would cost in the order of $100 million. If Delta water were usable, EBMUD could take delivery of its American River contract instead of going through an intertie with CCWD. **There is a possibility that a limited quantity, about 15 MGD, of treated water might be available on a seasonal basis from CCWD's Bollman Treatment Plant, but would be uncertain as to long-term availability. The pipeline and pumping plant required to deliver water from the treatment plant to the Mokelumne Aqueducts would cost about $1 million. An intertie with the South Bay Aqueduct could cost over $400 million for conveyance and treatment facilities. Studies can be undertaken to evaluate interties with other agencies but the amount of supply available from interties would be limited and uncertain. A consideration would be use of State Project water from the Santa Clara Valley Water District (SCVWD), which has several sources of supply, by wheeling it through the facilities and treatment plant of the Alameda County Flood Control and Water Conservation District Zone 7 in the Livermore Valley. The limited capacity for treatment in Zone 7 would restrict this option to only 5-10 MGD. A pipeline and pumping plant would be required, but feasibility is uncertain and a specific project has not yet been developed. The cost may be on the order of $10 million.**

## Other Additional Supply Sources

EBMUD's original decision to select the American River as the source for a supplemental supply of water and the subsequent negotiations which resulted in the execution of the USBR Contract in 1970 were based primarily on the quality of water available and the certainty of the water supply under a contract with the USBR. A review of other suggested sources which were considered before and since that decision shows that there are no feasible alternatives to the American River. The American River is still the best available source of water. The following is a discussion of the other suggested sources of supply.

### DELTA WATER SUPPLY

In late 1977 and early 1978, EBMUD received an emergency delivery of approximately 25,000 acre-feet of water by pumping from Middle River in the Delta. This was necessary because the 1976-77 drought significantly reduced EBMUD's Mokelumne supply.

However, the Delta has the major disadvantage of being a lower quality source than EBMUD's Mokelumne supply, particularly during droughts when the flow from the Sacramento River is not sufficient to repel the intrusion of sea water from San Francisco Bay. There is a concern about future public health risks associated with contaminants like trihalomethanes. Furthermore, EBMUD's water treatment facilities and processes are based on using a high quality source of water and would require pretreatment facilities at the source to remove turbidity, disinfect, and reduce the THM formation potential and other improvements to treat Delta water. In 1977, EBMUD had first-hand experience of the adverse effects which can result from the use of Delta water. These problems are described later in Chapter IV.

Any supply from the Delta would have to be obtained under contract with the State of California or the USBR, and the amount would be subject to negotiation of an agreement. The estimated cost of the additional facilities necessary to treat the lower quality water in the range of $200 to $370 million, in 1988 dollars. This cost is much greater than the estimated $105 million needed to implement the supplemental supply under the USBR contract. In addition, a diversion facility in the Delta would have potential impacts on the fishery resources and would require extensive screening facilities to minimize these impacts.

Because of the water quality problems and associated high treatment costs, the Delta is not a feasible planning alternative, especially since one of the District's primary goals is to provide the highest quality water to its customers. However, this does not preclude the use of Delta water for short periods of time in an emergency when there is no other option available.

### WOODBRIDGE IRRIGATION DISTRICT (WID) EXCHANGE

**Agreements between EBMUD and the Woodbridge Irrigation District and Woodbridge Water Users Conservation District provide that EBMUD will release enough water from Camanche Reservoir each year so that a Permanent Regulated Base Supply of 39,000 to 60,000 acre-feet, depending on inflow to EBMUD's reservoirs, is available for use by the Woodbridge districts; with sufficient additional releases so that an Interim Supply of 26,855 to 56,700 acre-feet, depending on inflow and EBMUD's diversion, is also available to those districts through 1992, unless terminated earlier by any party. These agreements recognize the relative rights to Mokelumne River water held by each district.**

**One concept of a Woodbridge exchange would provide a water supply to the Woodbridge districts from some other source in exchange for a commitment by those districts to reduce their Mokelumne River diversions. A source to Woodbridge could be from the Eastern Delta (about $25 million for new facilities). A small amount of water could also be available from possible groundwater sources in the Woodbridge area. The Woodbridge exchange would have a limited benefit to EBMUD because of the limited quantity of water involved, but it could help solve EBMUD's problem of shortage in drought periods somewhat.**

**Another concept developed by EBMUD was the purchase of water from the Woodbridge districts and other water users on the lower Mokelumne River, which could increase the amount of water available to EBMUD in dry years. Discussion between EBMUD and the Woodbridge districts on this approach is continuing. However, in both these concepts, the resulting decrease in river flows below Camanche Dam is a significant concern to the fish and wildlife agencies and would have an adverse impact on the groundwater basin unless recharge in normal and wet years can be enhanced.**

**A third concept EBMUD recently investigated was the possibility of pumping back Delta water to Camanche Reservoir to provide water for instream uses and crop irrigation downstream of Camanche Dam during drought conditions. This project**

**would have allowed more high quality Mokelumne water to be stored in Pardee Reservoir to be used as drinking water for 1.1 million people. However, the State Water Resources Control Board (SWRCB) recently denied this drought emergency request. One of the reasons for the denial was the SWRCB's conclusion that the project would harm lawful users of the water. Specifically, the proposed project would have temporarily increased the trihalomethane levels (up to maximum levels of 1 to 5 ug/L) and sodium levels (from 8 to 70 mg/L in a few wells) in Lodi's groundwater drinking water supply. The SWRCB concluded that evidence presented was insufficient to show that the increased concentrations of these constituents would not harm Lodi residents.**

## MOKELUMNE RIVER PROJECTS

The suggestion has been made that EBMUD could construct one or two new dams on the Mokelumne River above Pardee Reservoir to increase the yield from Pardee Reservoir. However, EBMUD is expressly prohibited by a 1958 agreement with Amador County from filing any new applications on the Mokelumne River to take additional water for consumptive use.

Furthermore, when EBMUD proposed the Middle Bar and Railroad Flat projects on the Mokelumne River, Amador County and the Amador County Water Agency filed a lawsuit against EBMUD for breach of contract even though the projects were to be used for hydroelectric purposes only. In addition, legislation has been introduced to create a "river recreational area" in the area that would have been inundated by the Middle Bar project. The intent of this legislation was to preclude future development in any river recreational area. This alternative has serious legal obstacles.

## STANISLAUS RIVER PROJECT - NEW MELONES RESERVOIR

The New Melones Dam and Reservoir on the Stanislaus River was completed in 1980 and would have a firm yield of 180,000 acre-feet in the year 2020. However, the water requirements of users within the Stanislaus river basin is projected to be about 131,000 acre-feet. The remaining 49,000 acre-feet of yield is not available because it has already been allocated to other areas within the Central Valley Project.

## COSUMNES RIVER PROJECT

The Cosumnes River Project Association has had plans for several years to develop the yield of the Cosumnes River. The water rights to most of the remaining unappropriated Cosumnes River water are held by the State. However, the Cosumnes River has been named a candidate for the Wild and Scenic River designation, making the construction of any project on the river difficult.

Figure III-35 summarizes the alternatives for supply.

## Alternatives to Reduce Water Shortages

Figure III-35

| ALTERNATIVE | REMARKS |
|---|---|
| 1. DO NOTHING | Continue present levels of water conservation and reclamation, which would save about 4.0 MGD by 2020. |
| 2. WATER CONSERVATION (Additional Measures) | Continue to implement existing program which would save about 4.0 MGD by year 2020; additional feasible measures would save about 6 MGD by 2020. |
| 3. WATER RECLAMATION (Additional Projects) | Complete the Chevron Refinery cooling water project in Richmond and develop and construct Alameda Golf Course irrigation project (total reduction in demand of 5.2 MGD). Develop and construct irrigation project in San Ramon Valley for golf courses and greenbelts (reduces demands by up to 1.4 MGD). |
| 6. WATER BANKING (Additional Terminal Storage) | Construct terminal reservoir at either Pinole, Buckhorn, or Los Vaqueros to provide 50,000 to 155,000 acre-feet at a cost between \$65 million to \$180 million. Filling cost would be between \$4 and \$17 million. |
| 7. INTERTIES WITH OTHER AGENCIES | Utilize existing interties or construct new interties with other water agencies. Raw water interties with San Francisco (Hetch Hetchy) and State Water Project (South Bay Aqueduct). Treated water interties with San Francisco (Hayward), CCWD, and Zone 7. |
| 8. DELTA WATER USE | Requires additional treatment facilities to use Delta water at a cost of \$200 to \$370 million. |
| 9. OTHER SOURCES | Exchange up to 39,000 acre-feet of additional Mokelumne water with Delta water with Woodbridge Districts if available, purchase Mokelumne water from Woodbridge District, or develop conjunctive use projects. |

NOTE: Alternative 4, Levee improvements in the Delta, and Alternative 5, New aqueduct pipeline across the Delta, are not applicable to drought shortages.

# Chapter IV
# Safety and Health: Maintain High Quality Water

## BACKGROUND

The District has had a historic commitment to provide its customers a drinking water supply which is safe, reliable, and free from taste and odor problems. When the East Bay Municipal Utility District was formed in the 1920's, it secured a high quality source from the Mokelumne River. Less expensive sources from the Sacramento-San Joaquin Delta and local groundwater were available, but the founders believed that the public would be served better by choosing a source of higher quality.

In its efforts to meet or exceed all present or potential state and federal standards, it is the District's policy to:

- Choose the highest quality source available when selecting or improving the water supply system.
- Take active measures to protect the supply from pollution.
- Implement the treatment improvements necessary to minimize contaminants and to eliminate taste and odors by providing water of the highest quality.

The District's selection of the Mokelumne River as its primary water source exemplifies EBMUD's commitment to high quality water supplies. To protect this high quality source, EBMUD owns 42,000 acres of watershed lands and maintains a watershed management program including watershed reconnaissance, water quality monitoring, and land management and acquisition. The District has embarked on a $35 million treatment improvement program aimed at modernizing its treatment plants and improving its taste and odor control capabilities by the addition of ozone and granular activated carbon at its Sobrante and Upper San Leandro Filter Plants. The District continues to pursue advanced treatment technology to assure compliance with future drinking water regulations and to minimize the amount of chemicals required for water treatment.

### Problem

A primary concern is the need, discussed in Chapters II and III, for EBMUD to increase its supply availability to have high quality water during outages and periods of drought. During these times, when the Mokelumne supply could be totally severed or severely limited, alternative supplies must be used. Alternative supplies from the Delta present numerous water quality problems. Based on its experiences with the Delta water during the 1976-77 drought, EBMUD's specific concerns include excessive salinity, high trihalomethane formation potential (formation of cancer-causing compounds), taste and odors, and limitations of the District's system in treating the Delta supply.

There is also a need to protect the District's existing sources from potential contamination and pollution. EBMUD protects the quality of its existing supply by monitoring and, where possible, controlling activities within the watersheds that could lead to contamination.

EBMUD provides very high quality water to its customers although summertime algal growth regularly causes taste and odor problems in the El Sobrante and San Leandro areas. While not posing health and safety risks, taste and odor problems are a serious aesthetic and economic problem because customers will seek more expensive alternatives including bottled water and home treatment devices.

EBMUD's treatment plants range in age from 21 to 67 years and are in need of modernization. Because of current and anticipated regulatory requirements, EBMUD needs to continue to pursue advanced water treatment technology.

Supplies meeting today's water quality standards will not necessarily meet future health requirements. In selecting new sources of water, EBMUD needs to obtain the best water source available. EBMUD has determined that the American River is the best available supplemental source.

### Importance of Source

Both the Federal Environmental Protection Agency (EPA) and the State of California Department of Health Services (DOHS) recognize the significance of high quality source waters as they relate to the quality of treated water consumed by the public. DOHS has been designated by EPA as the "Primacy Agency" in California with the responsibility for promulgation and enforcement of drinking water standards. DOHS, in its recently published "Guidelines for Treatment of Surface Waters for Domestic Use" (April 1986), reiterated its long-standing policy that:

> "Water utilities should seek to obtain the cleanest water source practical and provide all reasonable protection of the supply from any known or potential contamination hazard."

In its recent Policy Statement on Water Quality, the American Water Works Association stated its support for the principle that water of the highest quality should be delivered to all consumers. The Association stated that: ". . .water should come from the highest quality source of supply available and be appropriately treated to meet supply industry criteria."

A major emphasis of new drinking water regulations will be on the reduction of organic chemicals. The majority of organic compounds that exist in public drinking water supplies have not yet been identified and are of unknown health significance. Therefore, supplies meeting today's water quality standards will not necessarily meet future public health requirements. It is important to note that trihalomethanes (THMs) were only discovered in drinking water in the early 1970's. Other contaminants which may also pose significant health risks are likely to be discovered in the future. These unknowns, coupled with the problems which are already known, provide an overwhelming argument for choosing the best available water source.

The high quality of the District's Mokelumne River (Pardee Reservoir) supply is exemplified in Figure IV-1. The significance of the parameters shown in Figure IV-1 is discussed in a following section on "Water Quality and Drinking Water Regulations".

## WATER TREATMENT REQUIREMENTS

The amount of treatment that is required for a supply depends upon the quality of that supply and the degree to which its watershed is protected from pollution. Because of the high quality of Pardee Reservoir and the protected nature of its watershed, minimal treatment processes are required. These include coagulation, filtration, and disinfection, which are commonly referred to as direct filtration.

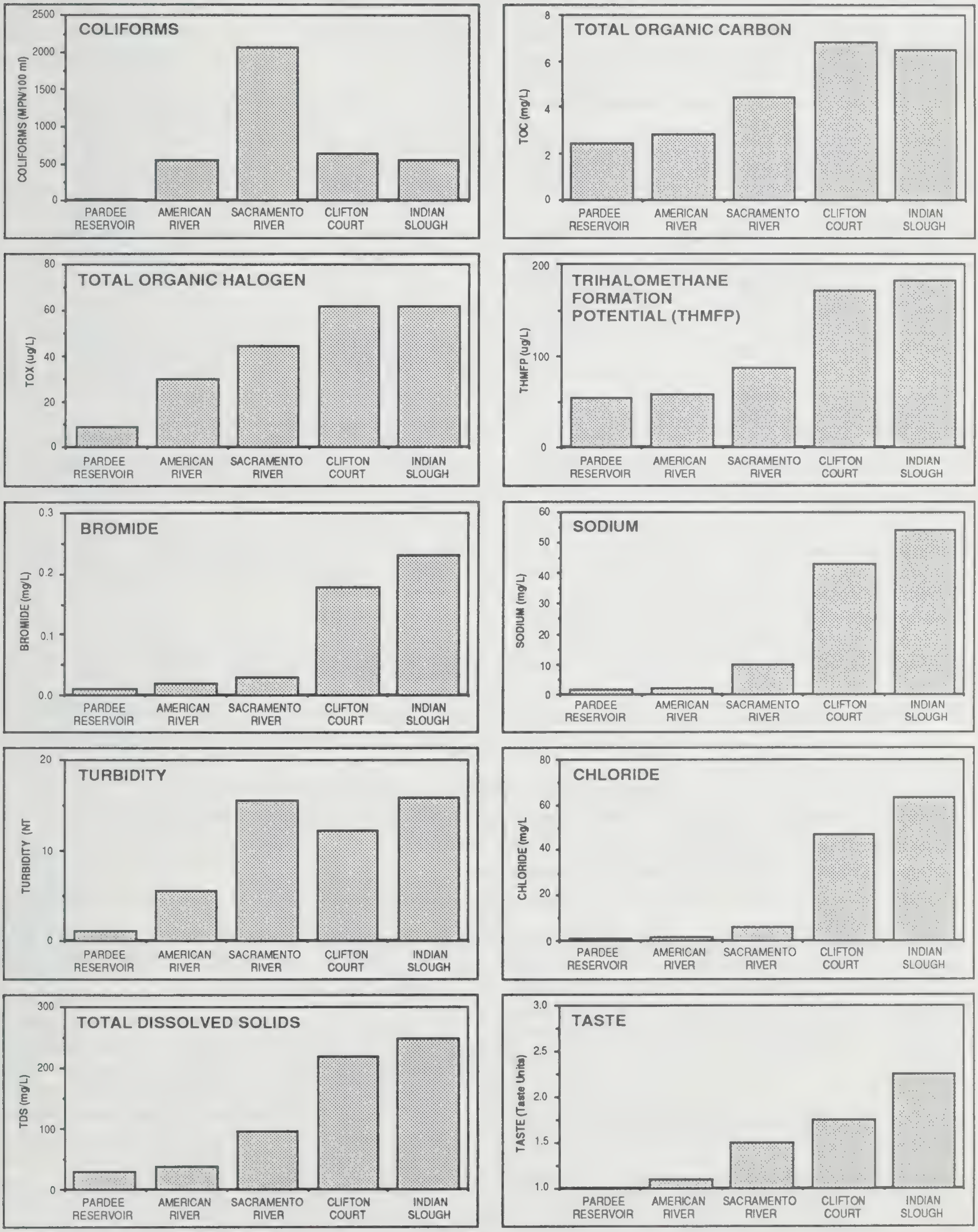
Urban development on a water supply watershed increases the probability of pollution of the water supply. These effects are described in a 1986 EBMUD report entitled "Urban Development and Runoff Effects on Water Quality" (EBMUD 1986). Water quality degradation associated with urban development is due to soil erosion caused by construction activities, sedimentation in streams and reservoirs and runoff from urban areas. Urban runoff causes increased risk of sewage and toxic spills, nutrient loadings which lead to taste and odors, organic loadings which lead to increased trihalomethanes, toxicity concerns due to contributions of metals and organics, increased contamination by disease-causing (pathogenic) organisms and increased soil erosion and reservoir siltation. Intensive agricultural use of land on a water supply watershed will also increase the probability of pollution of the water with chemicals including pesticides and herbicides.

As urban and agricultural development occurs, increasing levels of treatment are required to assure the safety of the water supply from both a health and aesthetic viewpoint. These additional treatment processes will substantially increase the cost of treating a supply for public consumption. Additional treatment facilities usually include aeration, flocculation, and sedimentation with increased water treatment chemical usage. These processes plus those in direct filtration are commonly referred to as conventional, or full treatment.

EBMUD operates six water treatment plants; three direct filtration plants which treat water directly from Pardee Reservoir and three full treatment plants which treat Pardee Reservoir water and local runoff which has been stored in local East Bay reservoirs. EBMUD's water treatment system is summarized in Figure IV-2.

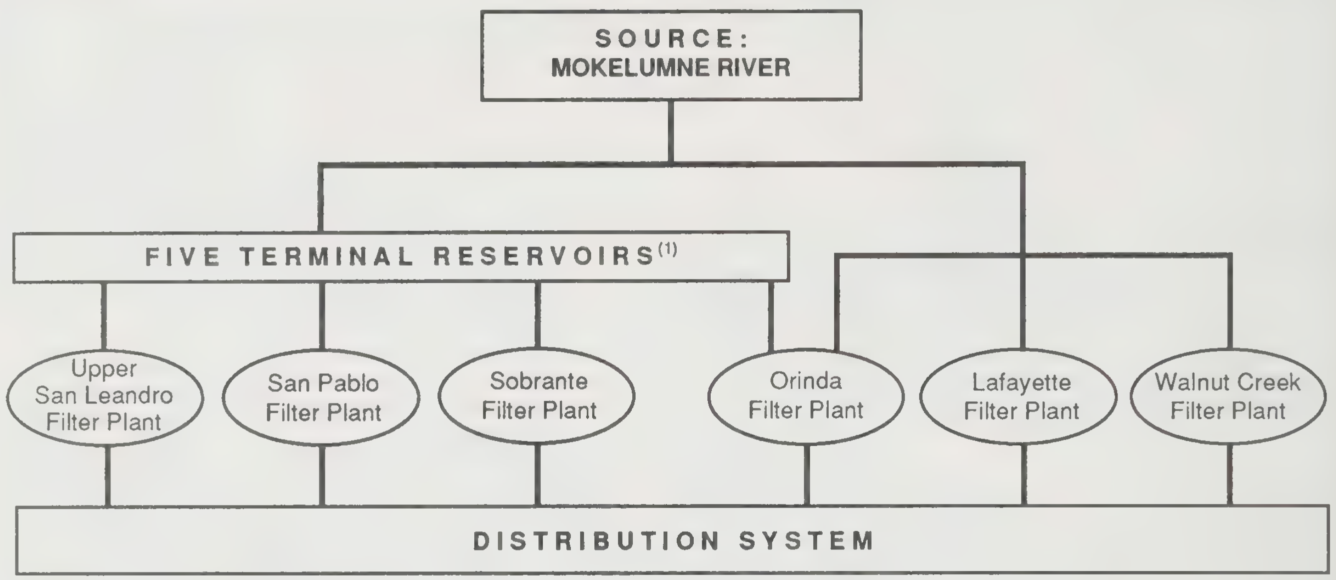
# EBMUD Raw Water Quality Monitoring Program Summary
# (August 1983—October 1987)

Figure IV-1



## EBMUD Water Treatment System

Figure IV-2




| SOURCE WATER | FILTER PLANT | TYPE OF TREATMENT | YEAR OF CONSTRUCTION | CAPACITY MGD |
|---|---|---|---|---|
| Pardee Reservoir | Walnut Creek | Direct Filtration | 1967 | 80 |
| Pardee Reservoir | Lafayette | Direct Filtration | 1953 | 42 |
| Pardee Reservoir<br>Briones Reservoir | Orinda | Direct Filtration | 1935 | 175 [2] |
| San Pablo Reservoir | San Pablo<br>Sobrante | Full Treatment<br>Full Treatment | 1921<br>1965 | 60<br>60 |
| Upper San Leandro Reservoir | Upper San Leandro | Full Treatment | 1927 | 83 |

NOTES:

(1) Chabot and Lafayette Reservoirs, small standby reservoirs, would only be used during extreme emergencies.

(2) Improvements under construction at Orinda Filter Plant will increase its capacity to 200 MGD by December 1988.

Chabot Filter Plant, a small plant constructed in 1890, is no longer in use.

Briones Reservoir can supply the entire system on an emergency basis.

As EPA continues to promulgate additional drinking water standards, even more treatment processes may be required. Use of the higher quality sources will minimize the necessity for costly facilities and reduce the amount of chemicals to be used for water treatment.

### IMPACT OF TERMINAL STORAGE ON WATER QUALITY

Mokelumne water that is not treated by the District's direct filtration plants is stored locally in the East Bay in terminal reservoirs before treatment. In addition to the degradation caused by urban runoff into these reservoirs, other factors including reservoir depth and detention time impact water quality.

The depth of a reservoir plays an important role in water quality control. During the winter and spring, runoff into the reservoir increases the water's turbidity (suspended particulate matter) and resultant treatment costs. During the summer and fall, the turbidity settles. As the water warms and clarifies, algae will grow in the upper portions of the reservoir. If water is taken from the upper portions of the reservoir, taste and odors, which can be very difficult to remove, result. If water is drawn from the lower portions of a reservoir

the higher turbidities found there increase treatment costs and anoxic conditions at the bottom may cause offensive taste and odors. Ideally a reservoir should be deep to allow the selection of water from various elevations in the reservoir to minimize taste and odors and treatment costs.

The detention time of a water in a reservoir can affect the level of mineralization of the water. If a water low in minerals, **such as Mokelumne water with an average TDS of about 40 ug/L,** is stored in a reservoir it dissolves minerals in the underlying strata resulting in higher levels of minerals in the water. As the detention time increases, the mineral content of the water will increase until it reaches an equilibrium level.

A summary of the water quality and some of the factors affecting water quality in the District's terminal reservoirs is shown in Figure IV-3.

Briones Reservoir provides a high quality supply because there is no urban development on the watershed and it is deep, 194 feet at the outlet tower. For these reasons, Briones water can be treated by the direct filtration process at Orinda Filter Plant. Briones Reservoir is used primarily for standby and consequently has a detention time of 7.2 years which causes the mineral content to increase to a moderate level.

San Pablo and Upper San Leandro Reservoirs, because of the extensive urban development on their watersheds and their shallow depths at the outlet towers, are subject to wide swings in water quality and persistent taste and odors in the summertime. The full treatment required for these reservoirs, although capable of removing turbidity at higher costs, has not been able to eliminate taste and odors. San Pablo Reservoir, because of its shorter detention time, has a lower mineral than the other terminal reservoirs.

Analysis of the water quality aspects of the various terminal reservoir alternatives under consideration is included in Chapter V.

## EBMUD EXPERIENCE WITH DELTA WATER

While the storage of Mokelumne water in terminal reservoirs helps to buffer the effects of urban runoff, the addition of other imported supplies can have a tremendous effect on the quality of the terminal reservoirs.

During the California drought of 1976-77, EBMUD had first-hand experience with treating Delta water on an emergency basis for municipal supply. Delta water was mixed with existing supplies and served to all customers in the EBMUD service area. The supply was withdrawn from Middle River upstream of Clifton Court Forebay. Middle River water was also pumped to Contra Costa Water District because of high salt levels in the Contra Costa Water District supply from Rock Slough (near Indian Slough in the west Delta). The high salt levels were caused by sea water intrusion into the Delta due to the absence of

## EBMUD Terminal Reservoir Water Quality

Figure IV-3

| PARAMETER* | AVERAGES | | | RANGES | | |
|---|---|---|---|---|---|---|
| | BRIONES | SAN PABLO | UPPER SAN LEANDRO | BRIONES | SAN PABLO | UPPER SAN LEANDRO |
| Total Dissolved Solids | 172 | 135 | 175 | 167—190 | 84—150 | 147—210 |
| Chloride | 8 | 8 | 13 | 6—10 | 6—11 | 11—15 |
| Sodium | 17 | 11 | 16 | 15—19 | 6.4—14 | 13—20 |
| Bromide | 0.10 | 0.08 | 0.12 | 0.03—0.2 | ND—0.2 | 0.04—0.3 |
| THM Formation Potential | 0.083 | 0.176 | 0.186 | 0.070—0.126 | 0.077—0.324 | 0.019—0.382 |
| Turbidity (NTU) | 0.87 | 8.9 | 5.4 | 0.4—9 | 0.8—50 | 0.6—70 |
| Taste (taste units) | 1.2 | 1.1 | 1.2 | 1—2 | 1—2 | 1—2 |
| Odor (odor units) | 1.3 | 1.6 | 1.5 | 1—2 | 1—2 | 1—2 |
| Coliforms (org/100 mL) | 33 | 332 | 177 | 0.9—170 | 4.9—1700 | 23—700 |
| Depth of outlet tower, feet | 194 | 94 | 79 | | | |
| Average detention time, years | 7.2 | 0.7 | 1.1 | | | |
| Watershed area, square miles | 9 | 23 | 30 | | | |
| Urban areas, square miles | 0 | 6.1 | 7.8 | | | |

*All values as averages in mg/L unless noted.
Data excerpted from "Water Quality Study," by J. M. Montgomery Engineers, 1983.

sufficient flows in the Sacramento River to repel brackish water from the ocean.

Because of its concern for trihalomethanes (THMs) (cancer risk) and sodium (hypertension and high blood pressure risk), DOHS limited the use of Delta water. EBMUD also experienced taste and odor problems from putting Delta water into two large local storage reservoirs. The amount of Delta water in San Pablo and Upper San Leandro Reservoirs rose to approximately 1/3 of total storage by the time the drought ended **(after 4-1/2 months of pumping Delta water).**

THMs presented the most serious health concerns. **With only a 10 percent blend of Delta water in the direct filtration plants, THM levels in the treated water reached levels as high as 115 ug/L. Trihalomethane levels in the treated water from the Orinda Filter Plant during the period in which Delta water was blended into the system in 1977 are shown on Figure IV-4A. During this period the amount of Delta water treated at Orinda Filter Plant fluctuated between 0 and 30 percent and averaged about 10 percent of the total. Treated water THMs rose to an average level of about 80 micrograms per liter (ug/L).**

**Use of Delta water in the terminal reservoirs had a similar but more lasting effect.** Figure IV-4B illustrates the influence of Delta water on Upper San Leandro Reservoir. The figure shows that the THM levels more than doubled following the introduction of Delta water to Upper San Leandro Reservoir. Average THM levels rose to approximately 70 ug/L.

The drinking water standard is currently 100 ug/L but serious consideration is being given within EPA to lowering the standard. The new standard will probably be in the range of 10 to 50 ug/L, significantly below the levels experienced by EBMUD when using Delta water.

Two important facts emerged regarding the effects of Delta water on THMs in Upper San Leandro Reservoir. The first was that it took approximately 5 years for the THM influence of Delta water to be flushed out of the reservoir. Secondly, a very high proportion of the THM's were brominated forms. EBMUD data confirmed the finding of high bromide content in the Delta. These data are summarized in Figure IV-4B. Brominated THMs are of significant concern because they are suspected to be more potent as carcinogens than chloroform (the most commonly occurring THM). The elevated bromide levels are caused by sea water intrusion, particularly in dry years, when Sacramento River water is not adequate to repel the intrusion.

EBMUD experience with Delta water during the drought confirmed that use of a lower quality source water can cause significant water quality and treatment problems. Contra Costa Water District (CCWD) normally takes its supply from the Delta at Rock Slough. During the Andrus Island flood in 1972, Delta water quality was degraded by salt water intrusion. CCWD requested emergency supplies from EBMUD to improve its water quality. During drought or flood, it is clear that Delta water would not meet EBMUD's need for high quality water.

### Protection of the Source

EBMUD protects the high quality of its sources in three ways:

WATERSHED RECONNAISSANCE

EBMUD patrols its watershed areas on a daily basis to detect fires, discourage trespassers, and regulate lease holders. All major proposed projects within the District's watersheds or adjacent to District property are reviewed so that their influence on watershed lands can be assessed. The District conducts periodic sanitary surveys of its watersheds in which all potential threats to water quality are evaluated. The District also maintains close contact with local officials so that they will contact the District immediately of any activities which could adversely affect the watershed.

WATER QUALITY MONITORING

The District maintains an extensive routine monitoring program to ensure that the quality of its sources is not deteriorating. A complete set of laboratory analyses are performed annually on all of the District's source waters. Additionally, some analyses are performed monthly, and others are performed every two hours at the treatment plants for process evaluation.

LAND MANAGEMENT AND ACQUISITION

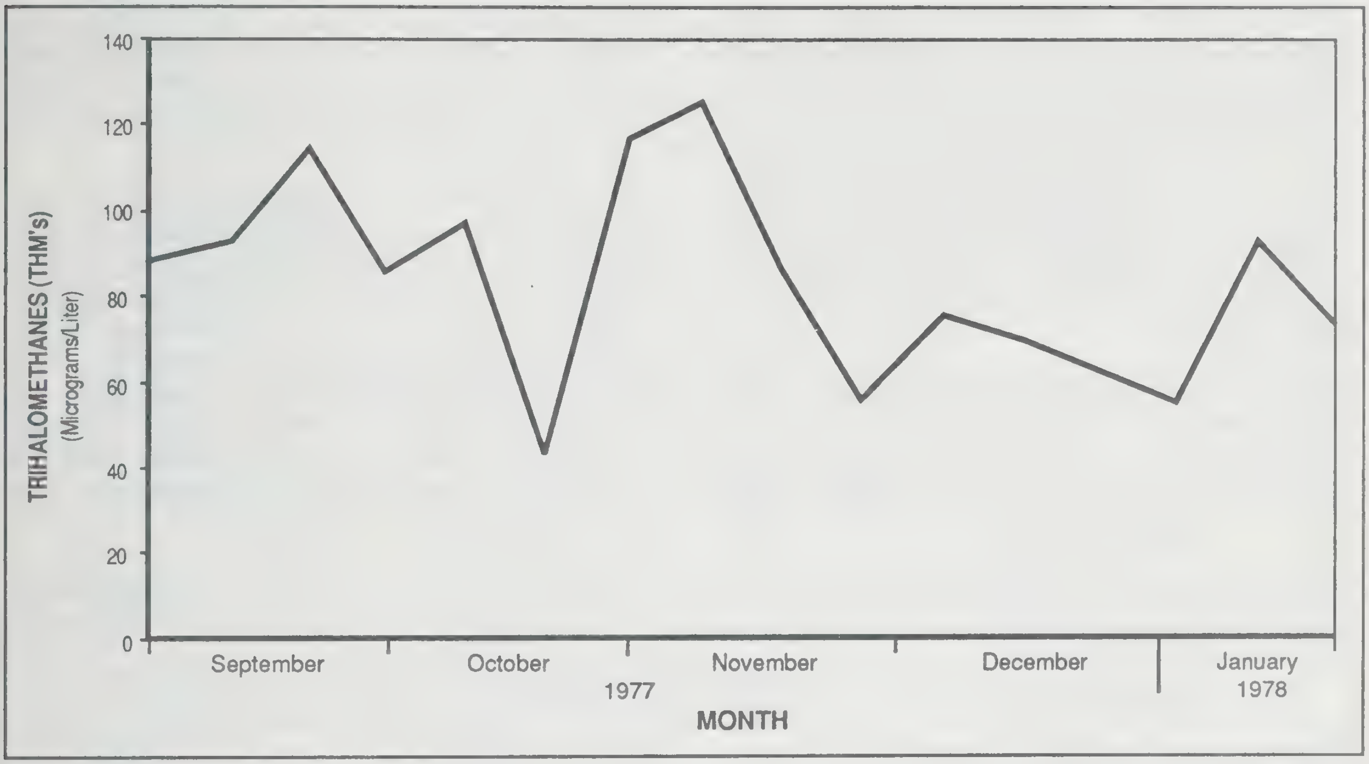
EBMUD's management of its watershed lands ensures that only those activities which are compatible with water quality preservation occur within the watershed. The management program includes vegetation control, erosion control, and land-use planning.

Vegetation control, to reduce fire hazards, is accomplished as much as possible through livestock grazing or mechanical means. The use of herbicides is kept to a minimum to prevent contamination of the reservoirs by runoff, and even then only quickly-decomposing, locally-applied herbicides are used.

To prevent the runoff of silts into the reservoirs, erosion is controlled with construction of silt retention structures and repair of erosion gullies. In addition,

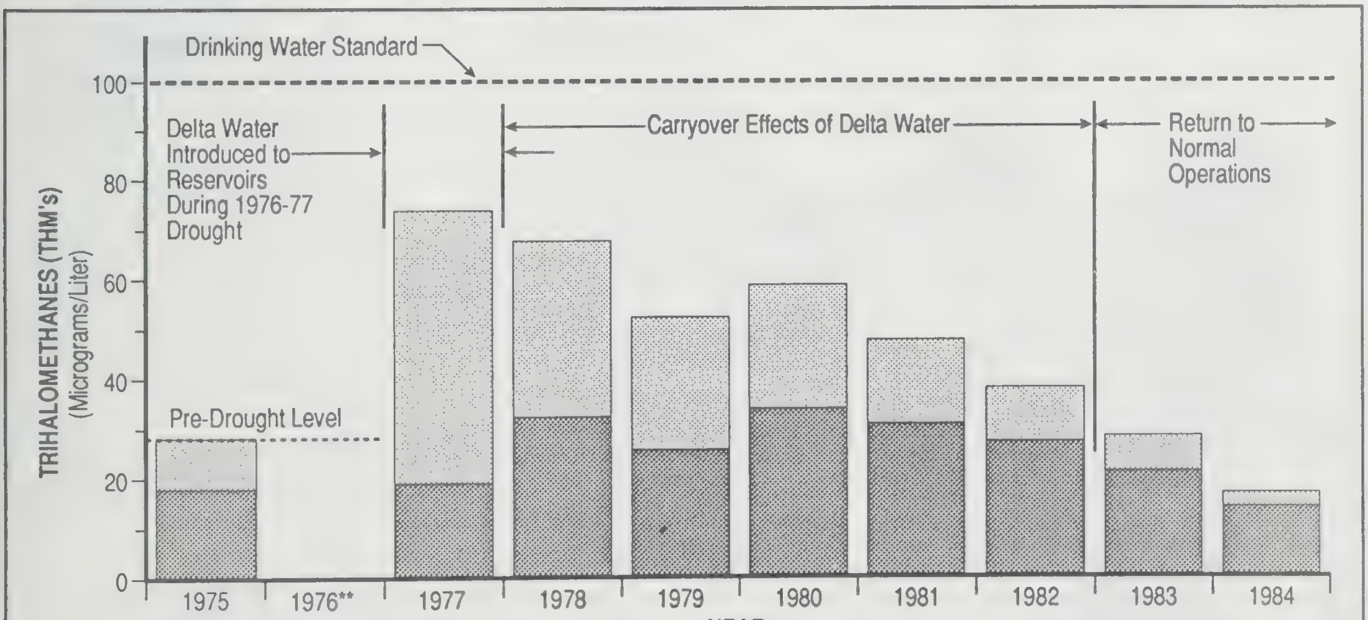
## Plant Effluent Trihalomethanes at Orinda Filter Plant

**September 1977 through January 1978** **Figure IV-4A**




## Impact of Delta Water on Terminal Reservoirs*

**Figure IV-4B**




*As measured in the effluent water from the Upper San Leandro Filter Plant.

**No data collected in 1976.

EBMUD cooperates with local governments to ensure that nearby grading projects do not cause erosion.

Land use planning is necessary to prevent adverse impacts on water quality from influences such as urban pollution and septic tank leakage and sewer overflows to surface streams. The remedies employed by the District include: land zoning to prevent excessive development, requirement of mitigation measures for development, support of septic tank regulations, and land exchange/purchase to ensure that key watershed lands are protected and not used in a manner that would threaten water quality and public health.

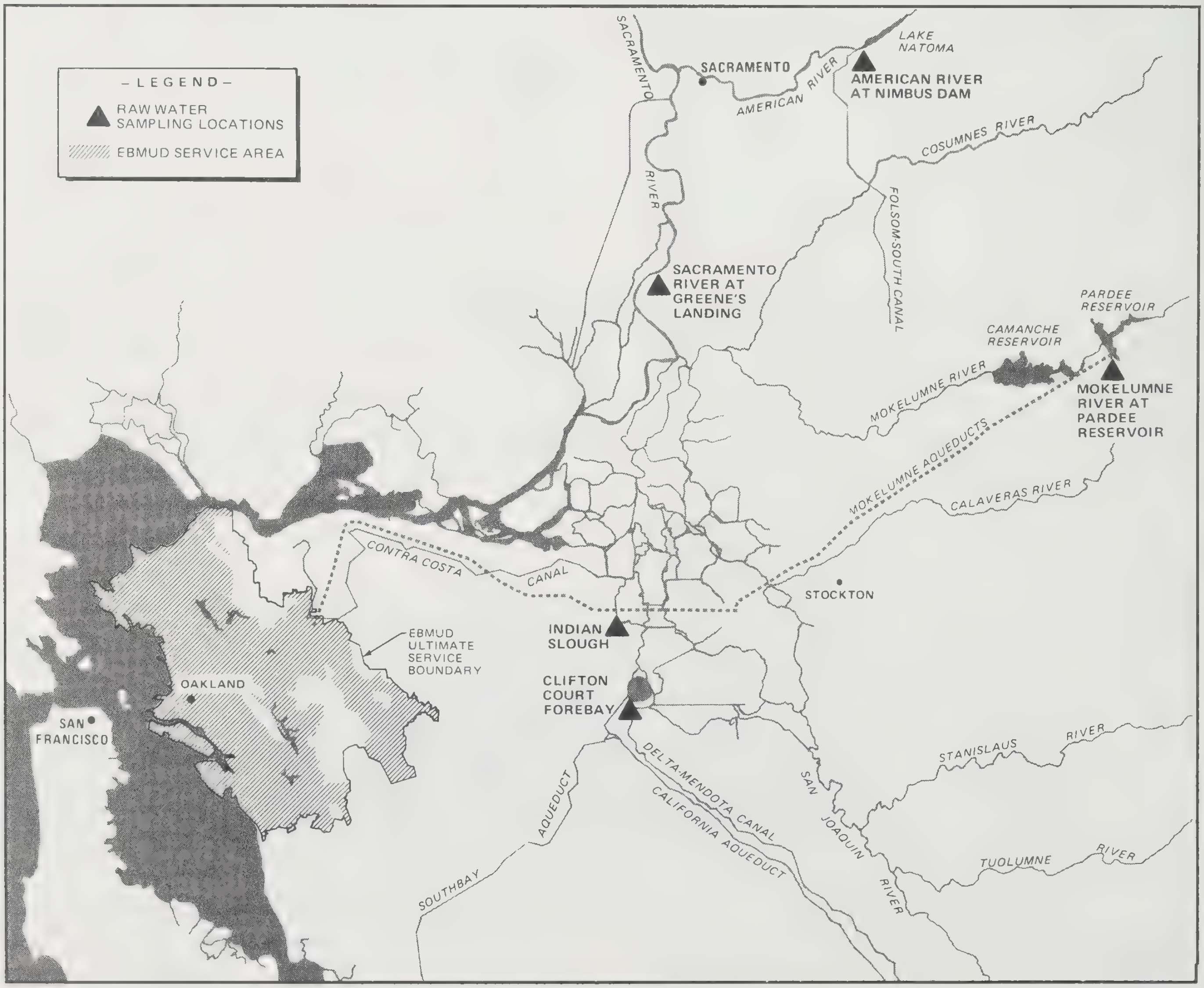
## Water Quality and Drinking Water Regulations

A summary of selected constituents from EBMUD's raw water quality monitoring program results is shown in Figure IV-1. The summary compares the water quality at the following sites: Mokelumne River at Pardee Reservoir, the American River at Nimbus Dam, the Sacramento River at Green's Landing, and the Delta at Clifton Court Forebay and Indian Slough. The selected sampling locations are shown in Figure IV-5. As that figure shows, the Mokelumne River is a superior source.

In 1986, the Federal Safe Drinking Water Act was amended to more than triple the number of regulated contaminants over the following three years. The EPA has been directed by Congress to promulgate national primary drinking water regulations for 83 contaminants by June 1989. These contaminants were listed in the Federal Register on March 1982 and October 1983 and are shown in Figure IV-6. The EPA is now preparing new drinking water regulations to implement these amendments. The emphasis in the

## Source Sampling Locations

Figure IV-5



# List of Contaminants Regulated by the U.S. Government

Figure IV-6

## List of Volatile Organic Chemicals (VOCs)

| | |
|---|---|
| Trichloroethylene | Benzene |
| Tetrachloroethylene | Chlorobenzene |
| Carbon tetrachloride | Dichlorobenzene(s) |
| 1,1,1-Trichloroethane | Trichlorobenzene(s) |
| 1,2-Dichloroethane | 1,1-Dichloroethylene |
| Vinyl chloride | cis-1,2-Dichloroethylene |
| Methylene chloride | trans-1,2-Dichloroethylene |

Source: Fed. Reg. 47:43 (Mar. 4, 1982)

## List of Other Contaminants Referenced by Amendments

### Synthetic Organic Chemicals (SOCs)

| | | |
|---|---|---|
| Endrin* | Glyphosphate | Pentachlorophenol |
| Lindane* | Carbofuran | Pichloram |
| Methoxychlor* | 1,1,2-Trichloroethane | Dinoseb |
| Toxaphene* | Vydate | Alachlor |
| 2,4-D* | Simazine | 1,2-Dibromomethane (EDB) |
| 2,3,5-TP (Silvex)* | Polynuclear aromatic hydrocarbons (PAHs) | Epichlorohydrin |
| Total Trihalomethanes (TTHM)* | Polychlorinated biphenyls (PCBs) | Dibromomethane |
| Aldicarb | Atrazine | Toluene |
| Chlordane | Phthalates | Xylene |
| Dalapon | Acrylamide | Adipates |
| Diquat | 1,2-Dibromo-3-chloropropane (DBCP) | Hexachlorocyclopentadiene |
| Endothall | 1,2-Dichlorpropane | 2,3,7,8-TCDD (Dioxin) |

### Inorganic Chemicals (IOCs)

| | | |
|---|---|---|
| Arsenic* | Silver* | Vanadium |
| Barium* | Fluoride* | Sodium |
| Cadmium* | Aluminum | Nickel |
| Chromium* | Antimony | Zinc |
| Lead* | Molybdenum | Thallium |
| Mercury* | Asbestos | Beryllium |
| Nitrate (as N)* | Sulfate | Cyanide |
| Selenium* | Copper | |

### Microbiological Contaminants

| | | |
|---|---|---|
| Turbidity* | Viruses | Filtration of surface water |
| Total Coliforms* | Standard plate count | Disinfection of all water |
| Giardia lamblia | | |

### Radionuclides

| | | |
|---|---|---|
| Radium-226 and 228* | Beta particle and photon radioactivity* | Uranium |
| Gross alpha particle activity* | | Radon |

Source: Fed. Reg. 48:194 (Oct. 5, 1983)
*Already regulated

new regulations will be on reduction of organic chemicals in drinking water, filtration of surface water supplies, and disinfection of all water supplies.

Figure IV-7 illustrates the fact that the number of water quality standards being promulgated is accelerating. Even with the increased efforts at setting standards, a vast number of organic compounds are not yet regulated.

HEALTH RISKS OF SPECIFIC SUBSTANCES

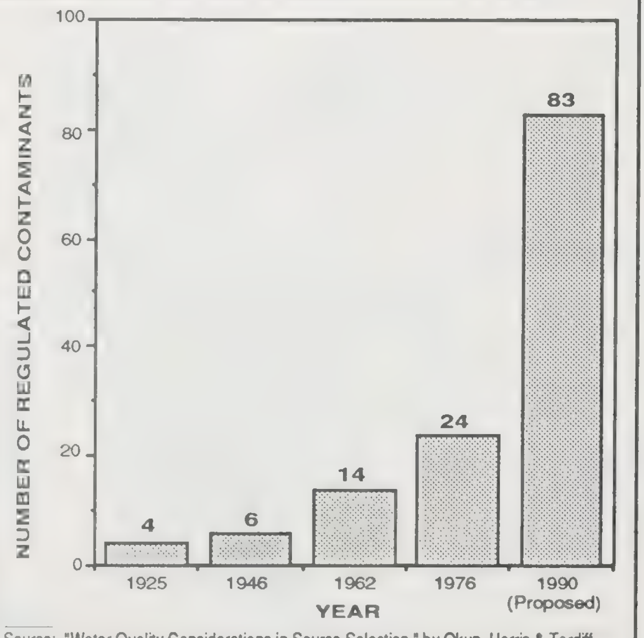
Priority is given to the health-related aspects of water quality for which "primary" standards (maximum contaminant levels, or MCLs) were established by EPA and which are enforced by DOHS. Most of the contaminants for which primary standards were established have not been detected in the District's raw or treated waters, and those that have been are presently at levels well below the MCLs. Current values for these standards are listed in Figure IV-8, along with the average values determined for the District's treated water.

The following paragraphs summarize a selection of constituents considered to be of particular importance in regard to public health effects.

**Pathogens** (disease-causing microorganisms) have historically been the primary impetus to treat water. Until the twentieth century, waterborne protozoa, bacteria, and viruses caused disease outbreaks, resulting in widespread illness and death. With the advent of disinfection, such outbreaks have been substantially eliminated. Disinfection continues to be a critical element of water treatment due to recently identified concerns regarding the potential contamination of water supplies with two protozoa, Giardia and Cryptosporidium.

## Number of Contaminants Regulated by the U.S. Government

Figure IV-7



Source: "Water Quality Considerations in Source Selection," by Okun, Harris & Tardiff

**Coliform bacteria** are used as an indicator of the potential presence of pathogenic organisms in water. As can be seen in Figure IV-1, average total coliform levels in Pardee Reservoir are very low.

**Total Organic Carbon (TOC)** is the parameter most commonly used as an indicator for organic compound content in water samples. Little is known about the health risks that organic compounds pose. It is therefore safer to minimize the concentration of all of these organic compounds, as represented by TOC. As shown in Figure IV-1, the TOC concentration in Pardee Reservoir is about 2-½ times less than that in the Delta.

**Synthetic Organic Compounds (SOCs)** may occur in water as the result of contamination from hazardous waste sites and industrial and agricultural discharges. The EPA has proposed MCLs for several volatile SOCs based on their carcinogenicity and has identified more for probable regulation. The levels of volatile SOCs proposed for regulation have always been below detection limits in EBMUD's source waters.

**Trihalomethanes (THMs)** are disinfection by-products and cancer causing compounds resulting from the disinfection of water with chlorine, which reacts with naturally occurring organic compounds to form THMs. The most significant known health risk in treated surface supplies is caused by THMs. The standard for THMs is currently 100 ug/L, but there is serious consideration within EPA to lower it to 10 to 50 ug/L. EBMUD's THMs are now about 25 ug/L.

**Trihalomethane Formation Potential (THMFP)** is a scale established by laboratory tests under conditions similar to disinfection to measure the potential that a water source has for producing THMs. Studies have shown that the use of a water supply source lower in THMFP can be expected to result in lower THMs after treatment. As Figure IV-1 shows, THMFP in Pardee Reservoir is substantially lower than in Delta waters.

**Total Organic Halogen (TOX)** is a measure of the organic compounds associated with chlorine, bromine, and iodine, including trihalomethanes. Since most halogenated organics are suspected of being toxic or carcinogenic, the TOX in water is a useful indicator of

toxic contaminants. TOX is low in Pardee Reservoir as can be seen in Figure IV-1.

**Pesticides** applied to agricultural lands can migrate into the surface water that drains the watershed. Currently only seven pesticides are regulated, and although water sample analyses have rarely revealed detectable levels of pesticides in the Delta, the high level of pesticide use in the Sacramento and San Joaquin River watersheds is sufficient to suggest that the Mokelumne and American Rivers represent lower health risk vis-a-vis pesticides. Pesticides have never been detected in Pardee Reservoir or the terminal reservoirs.

**Inorganic Chemical Compounds** consist primarily of heavy metals, such as lead and mercury, and minerals, such as nitrates or fluorides. The behavior and health effects of most inorganic compounds in water are well known and MCLs have been set by EPA. Some inorganic materials, such as selenium and fluoride, have desirable minimum as well as maximum values; the level of fluoride is, in fact, maintained between the minimum and maximum levels as part of the treatment process. The District's raw water sources meet the MCLs as shown in Figure IV-8. The major concern of inorganic compounds is their impact on the aesthetic qualities and customer costs, which are discussed later.

**Sodium** is an essential element in the human diet; however, evidence from epidemiologic, clinical, and animal studies suggests that chronic excessive sodium intake is associated with hypertension, defined as an increase in blood pressure. The American Heart Association (AHA) has advocated a sodium-restricted diet for the long-term management of hypertension and has suggested a maximum level of sodium in drinking water of 20 milligrams per liter (mg/L) (NRC 1980).

Figure IV-1 illustrates the low sodium levels in Mokelumne water compared with higher sodium levels in Delta sources. Historically, studies confirm that sodium levels in the Delta (Clifton Court and Indian Slough) are above the suggested maximum. In Mokelumne water, on the other hand, sodium levels are well below the recommended maximum.

**Turbidity** is an indication of the level of particulate matter suspended in water. High turbidity water is not only visually unacceptable to the consumer; it can shield microorganisms from the action of disinfectants. Furthermore, many inorganic and organic molecules associated with particulate matter in raw water demonstrate a capacity to react with and consume the chlorine or other disinfectant added to raw water (termed a disinfectant demand). Therefore, higher "demand" waters require greater dosages of chlorine in order to achieve adequate disinfection. These greater dosages of chlorine in turn increase the potential for THM formation.

The EPA has set an MCL for turbidity of 1 turbidity unit (NTU) to assure that the concentration of particulates in treated water is compatible with current disinfection techniques. Regulations proposed subsequent to the 1986 Safe Drinking Water Act Amendments would lower the MCL to 0.5 NTU or less at least 95 percent of the time. Figure IV-1 illustrates the low turbidity level in Pardee Reservoir before treatment.

## AESTHETIC QUALITY

The aesthetic quality of drinking water is one of the most important indicators of its acceptability to consumers. Secondary Drinking Water Standards were established to regulate certain characteristics and chemical constituents of drinking water which may be aesthetically objectionable but which are not hazardous to health at levels found in drinking water (Department of Health, 1977). These standards require utilities to protect the public welfare by assuring a supply of pure, wholesome and potable water. A list of the constituents regulated by these standards and the levels of these constituents in EBMUD water are given in Figure IV-9.

Pardee Reservoir provides consistently good tasting water because it is very low in minerals, is not plagued with algal blooms, and requires very little chlorine for disinfection. Briones Reservoir provides good tasting water because the runoff from its protected watershed results in minimal algal blooms and the depth of the reservoir allows careful selection of water at various elevations in the reservoir. However, San Pablo and Upper San Leandro Reservoirs are routinely affected by taste and odors as previously described. The best defense against taste and odor problems is a high quality source water with multiple treatment steps for taste and odor control.

Figure IV-1 shows the high quality of Pardee Reservoir and the American River relative to the Delta with respect to average mineral (chloride and total dissolved solids) and taste and odor levels. While the levels of the constituents are relatively uniform in Pardee Reservoir and the American River, they are subject to wide variation in the Delta due to the variability of inflows to the Delta, particularly during dry years.

## Primary Drinking Water Standards (1986)

Figure IV-8

| PRIMARY STANDARDS<br>Mandatory, Health-Related Standards Established by Environmental Protection Agency | | | | |
|---|---|---|---|---|
| PARAMETER | UNIT | MAXIMUM CONTAMINANT LEVEL (MCL) | EBMUD LEVEL* | |
| | | | RANGE | AVERAGE |
| **CLARITY** | | | | |
| Turbidity | NTU | 0.5 — 1 | 0.05 — 0.20 | 0.10 |
| **MICROBIOLOGICAL** | | | | |
| Total Coliform Bacteria per 100 mL | | 1 | 0 — 0.19 | 0.02 |
| **ORGANIC CHEMICALS** | | | | |
| Total Trihalomethanes (TTHM) | ppb | 100 | 6—44 | 25 |
| Pesticides | ppb | 0.2 — 100 | ND | ND |
| **INORGANIC CHEMICALS** | | | | |
| **HEAVY METALS** | | | | |
| Arsenic | ppb | 50 | ND — 10 | ND |
| Barium | ppb | 1000 | 7 — 73 | 15 |
| Cadmium | ppb | 10 | ND — 1 | 0.16 |
| Chromium | ppb | 50 | ND — 5 | 1.6 |
| Lead | ppb | 50 | ND — 10 | 3.6 |
| Mercury | ppb | 2 | ND — 0.30 | ND |
| Selenium | ppb | 10 | ND — 7 | ND |
| Silver | ppb | 50 | ND — 3 | 1.1 |
| **MINERALS** | | | | |
| Fluoride | ppm | 1.4 — 2.4 | 0.7 — 1.0 | 0.85 |
| Nitrate (as $NO_3$) | ppm | 45 | ND — 3 | 0.10 |
| **RADIONUCLIDES** | | | | |
| Gross Alpha (including Radium-226 and 228) | pCi/L | 15 | ND — 0.3 | 0.1 |
| Tritium | pCi/L | 20,000 | ND | ND |
| Strontium-90 | pCi/L | 8 | ND | ND |
| Gross Beta | pCi/L | 50 | ND — 2.2 | 1.3 |

**Abbreviations and Units**

NTU = Turbidity unit
ND = Not detected
ppm = parts per million (milligrams per liter)
ppb = parts per billion (micrograms per liter)
pCi/L = picocuries per liter

*Ranges were determined over an 8 year period (1980-87) except TTHM (1987), Radionuclides (1983) and Turbidity (1987).

### Customer Costs

In 1983, J. M. Montgomery Engineers conducted a water quality study for EBMUD which identified and quantified water quality related costs to consumers and industrial users. The following summarizes their findings. All costs are in 1983 dollars. Identifiable consumer costs affected by water quality can include purchase of bottled water, use of home softeners, higher consumption of soap and detergents, more frequent replacement of water heaters, and corroded household plumbing.

Consumer use of bottled water depends on public perception of water quality, including perceived taste, odor and mineralization. Use of bottled water can be

## Secondary Drinking Water Standards (1986)

Figure IV-9

**SECONDARY STANDARDS (1986)**
**Aesthetic Standards Established by California Department of Health Services**

| PARAMETER | UNIT | MAXIMUM CONTAMINANT LEVEL (MCL) | EBMUD LEVEL* | |
|---|---|---|---|---|
| | | | RANGE | AVERAGE |
| **PHYSICAL PARAMETERS** | | | | |
| Color | units | 15 | 2—12 | 4 |
| Odor—Threshold | units | 3 | ND—9 | Less than 1 |
| **CHEMICAL PARAMETERS** | | | | |
| Copper | ppm | 1 | ND—0.021 | 0.006 |
| Corrosivity | MPY | Relatively low (<10) | 1—7 | 3 |
| Iron | ppm | 0.3 | ND—0.100 | 0.05 |
| Manganese | ppm | 0.05 | ND—0.032 | 0.003 |
| Foaming Agents (MBAS) | ppm | 0.5 | ND—0.03 | 0.02 |
| Zinc | ppm | 5.0 | ND—0.060 | 0.013 |
| Chloride | ppm | 250 | 2—25 | 3 |
| Sulfate | ppm | 250 | 1.1—60.5 | 5.6 |
| **MINERALS** | | | | |
| Total Dissolved Solids (TDS) or | ppm | 500 | 37—245 | 49 |
| Specific Conductance | µmho/cm | 900 | 41—411 | 70 |

**Abbreviations and Units**

ppm = part per million (milligrams per liter)
MPY = mils per year
µmho/cm = micromho per centimeter
ND = Not detected

*Averages were determined over a 6-year period (1980—85)

estimated to a first approximation from mineral levels (TDS). On this basis, average annual costs per household would range from $12 for Pardee Reservoir water to $26 for Indian Slough water. The actual spread may be greater because other factors, like odor, influence consumers to purchase bottled water also.

Estimates for consumer cost of home water softeners range from $0 per household per year for Pardee Reservoir water since softeners are not needed for Mokelumne water to $6 per household per year for Indian Slough water.

The estimated incremental annual cost per household (compared to the current Pardee Reservoir supply) for soap and detergent purchase, bottled water use, and home softeners would range from approximately $2 with American River water to $31 with Indian Slough water.

Other water-quality related consumer costs, especially replacement of household plumbing, may be significant. For categories of consumer costs, such as the use of at-the-tap purification units, insufficient data are available to estimate costs, although they are probably significant.

Identifiable water quality-related incremental costs to industrial users include chemical costs of demineralization, softening, and operation of cooling towers and boilers. Industrial users would be adversely affected by rapid changes in delivered water quality (which occurs in Delta water). Capital costs of industrial water treatment facilities are based on the highest level of mineralization (total dissolved solids) to be experienced. Use of 100 percent Delta water would require considerable capital investment by industry.

### CONCLUSIONS REGARDING SOURCE

The final quality of the water delivered to the consumer depends on two factors: the quality of the source water and the effectiveness of treatment. Figure IV-10 compares water quality control strategies relative to several water quality issues.

## Comparison of Water Quality Control Strategies

Figure IV-10

| WATER QUALITY ISSUES | WATER QUALITY CONTROL STRATEGY | | | CONCLUSIONS |
|---|---|---|---|---|
| | NO PROJECT | USE HIGH QUALITY/PROTECTED SOURCES | IMPROVE TREATMENT | |
| THMs | Probably will be unable to meet Disinfection Byproducts Rule. | Sources with low THMFP will be treatable with lower cost and/or to lower THM levels. | Probably will need some capital improvements; cost varies greatly with source water. | Use sources low in THMFP, improve treatment as required. |
| Taste & Odor | T&O will continue to be a seasonal problem with terminal reservoirs and when Delta is used as an emergency source. | T&O will continue to pose few or no problems for Sierra sources. | T&O in terminal reservoirs can be greatly reduced with GAC and ozone, but probably not eliminated. | Improve treatment; however, no amount of treatment can totally eliminate effect of source. |
| Excessive Salinity | Severe problem during extended outages of the Mokelumne Aqueduct when Delta is used as an emergency source. | Salinity is not a problem for any source except the Delta. | Tremendous cost associated with salinity removal. | Avoid Delta as a source. |
| Pesticides | Only a threat for relatively unprotected sources, e.g. Delta. | Protected sources with limited pesticide use in their watershed are the only sure method of avoiding health threats. | Can be treated, but "safe" levels not been defined and measurement is difficult. | Use protected sources, i.e., those not exposed to agriculture. |
| Chemical Contamination | Unprotected sources will continue to be subject to tanker truck spills, urban runoff, etc. | Protected sources offer the only protection from spills and urban development. | Impossible to treat gross contamination which could result from spill. | Use protected sources, i.e., those not exposed to development, urban runoff or heavy traffic. |
| Future Regulations | Likely that standards will be violated. | Many regulations will already be met for protected sources; any needed improvements will be relatively minor. | Treatment improvements will continuously be under construction, at great cost. No guarantee that all future regulations can be met with treatment alone. | Use protected source in order to allow maximum flexibility and improve treatment as required. |
| Unknown Organics | Human health effects unknown; assumed to be adverse. | The safest, surest method. | May or may not remove "enough" of the organics. | Use protected source to afford protection against unidentified contaminants. |

The sources available to the District are its Mokelumne River supply and the Delta in the near term plus the American River in the future. The District's water quality monitoring program, summarized in Figure IV-1, shows that the American River is the source most similar to the Mokelumne River and that Delta sources have the lowest water quality.

### Treatment Requirements

**If EBMUD were to plan on the intermittent use of Delta water as part of its long-term Water Supply Management Program, additional treatment facilities would be required by the California Department of Health Services to meet drinking water regulations.**

All of the District's treatment plants, particularly the direct filtration plants, would have to be modified. Sedimentation facilities at the direct filtration plants and the addition of ozone and GAC facilities (larger than now under construction at Sobrante and Upper San Leandro Filter Plants) at all of the plants would be required. This is not likely to be feasible at the direct filtration plants due to site constraints. The

alternative would be to construct one treatment plant with all of the processes near the Delta. Its treated water would be injected into the Mokelumne Aqueducts. The cost for such a plant (which would reduce the THMFP of Delta water to that of Mokelumne water) **and the necessary modifications to the full treatment plants** would be approximately $370 million.

**The capacity of the treatment facility near the Delta was assumed to be 170 million gallons per day to match the peak rate that would be used under EBMUD's existing contract with the U.S. Bureau of Reclamation for Central Valley Project water. The capital cost of this plant would be $165 to $200 million depending on the cost of ozone treatment, which is uncertain.**

**The treatment facility near the Delta would include coagulation, flocculation, sedimentation and sludge disposal facilities to reduce Delta water turbidity to that of the Mokelumne River before blending the Delta water with Mokelumne water in the Mokelumne Aqueducts.**

**Ozone and granular activated carbon processes would be used at the near Delta treatment facility to reduce the trihalomethane formation potential of the Delta water to 60 ug/L (equivalent to that of Mokelumne water). An ozone dosage of 2 mg/L at a five minute contact time was assumed. (Recent data indicates that this dosage should be substantially higher.) Filtration through granular activated carbon (GAC) for 15 minutes and regeneration of the GAC every two months on average was assumed.**

**Due to the higher nutrient levels in Delta water which would be introduced into EBMUD's local East Bay reservoirs and consequently increase algal activity and trihalomethane formation potential levels, ozone and GAC processes were added to EBMUD's treatment plants supplied by the reservoirs.**

**Ozone treatment at 1.5 mg/L for five minutes was added to the District's treatment plants which draw water from local East Bay reservoirs to which Delta water would be added. The cost of these ozonation facilities are not included in the $370 million since ozonation is currently planned for these existing treatment plants. GAC filtration was added to these treatment plants to reduce THM levels to a maximum of 30 ug/L. The GAC recently installed at these plants has a short contact time and is planned only for taste and odor control of the existing supply. GAC for taste and odor control may last five years, however, for THM control it may last for only a few weeks. Construction of new filters or contactors would be required to use GAC at these plants for THM control. The capital cost of these facilities would be $205 million.**

**Total capital cost of these treatment facilities is estimated at $370 million and would be higher if future THM standards are less than 30 ug/L. The capitalized operation and maintenance cost of these facilities, primarily due to the required frequent replacement/regeneration of the GAC, is $130 million.**

**If Delta water were to be considered a source in the event of a disaster in the Delta caused by a major earthquake and resulting in an extended outage of the Mokelumne supply, then desalinization facilities would be needed in addition to the above-described treatment facilities. It would enable the production of approximately 130 MGD of desalinated water and would produce 40 MGD of concentrated brine by a reverse osmosis treatment process. If the Delta water TDS were 2,000 mg/L the brine would be about 8,000 mg/L. Disposal facilities would have to be provided for the brine. The capital cost estimate for a 130 MGD desalinization facility is $75 million. Added to this would be the brine disposal costs which would include a pump station and pipeline sized to carry 40 MGD of brine to a location in or near San Francisco Bay. The capital cost estimate for brine disposal is $50-100 million.**

## Water Quality Impacts

Beyond the treatment cost differences among the sites, a greater, non-monetary difference exists: risk to public health. The Mokelumne and American river watersheds are protected from a multitude of natural hazards such as organic compounds (e.g., pesticides, urban storm runoff, chemical spills). The greater the hazard to the watershed, the greater the risk to public health, even with the best treatment available.

**The California Department of Health Services considered the cancer health risks associated trihalomethanes with three theoretical water systems:**

- **Water system (1) provides water with a constant THM level of 30 ug/L. (EBMUD average level is about 25 ug/L.)**
- **Water system (2) provides water with a constant THM level of 80 ug/L.**
- **Water system (3) varies between these levels where:**

- Normal THM levels are 30 ug/L.
- When Delta water is introduced, the level is 80 ug/L.
- Each use of Delta water lasts 6 months.

It was assumed that the total THM concentration is in the form of chloroform. In reality, there would be a combination of, at least, four THMs. Only chloroform is presently considered an animal carcinogen, however, it is suspected that brominated forms of trihalomethanes may be more potent carcinogens than chloroform.

The theoretical cancer risk assessment published by EPA at the time the THM regulation was promulgated (Federal Register, Vol. 44, No. 231, Thursday, Novembere 29, 1979) was used for the analysis. The risk assessment assumed one additional cancer case will occur in a million population at a concentration of 0.5 ug/L of chloroform. This assumes a 2 liter per day exposure over a 70-year lifetime. A more recent risk assessment by EPA suggested that the cancer risk from chloroform may be approximately 10-fold less. Refer to the comment letter of June 15, 1988 from Dr. David P. Spath of DOHS for a more detailed description of the analysis.

For water system (1), the absolute theoretical risk at 30 ug/L is 60 excess cancer cases per million population.

For water system (2), the absolute theoretical risk at 80 ug/L is 160 excess cancer cases per million population.

For water system (3), the absolute theoretical risks, for the intervals of intermittent Delta water use, are:

| | Time Interval, Years | | | |
|---|---|---|---|---|
| | 5 | 10 | 20 | 50 |
| Absolute Theoretical Risk, Excess cancer cases per million population | 70 | 65 | 62.5 | 61 |

The DOHS analysis was limited to the infrequent use of Delta water for six months at a time and a trihalomethane level of 80 ug/L. During actual drought or outage emergencies the use of Delta water could be required for longer than six months and trihalomethane levels in the system could be considerably higher. It is also important to note that in Chapter IV, THM levels in EBMUD's system could be elevated for several years due to a short period (a few months) of use of Delta water in EBMUD local reservoirs.

It is important to note that drinking water standards for cancer causing compounds are typically set at the level which causes one excess cancer case per one million in population. The current trihalomethane standard of 100 ug/L was based also on technical and economic factors and is expected to be lowered substantially by EPA within the next few years to better reflect health risks. The DOHS analysis of intermittent Delta water use by EBMUD concluded that there would be approximately 61 to 70 excess cancer cases per million in population. This is at least one to ten cancer cases per million more than what would theoretically occur without the intermittent use of Delta water. This analysis did not take into account other disinfection by-products which will be regulated by EPA within the next five years.

In addition to the increased health risk posed by **trihalomethanes and** the multitude of unidentified compounds in sources such as Delta water, certain health aspects as well as the aesthetic qualities of the chosen source water must be carefully considered. The average sodium levels in the Delta, for instance, are far above that recommended for people with hypertension. The seasonal high levels of chloride also pose a significant aesthetic problem (salty taste). It must also be realized that a supplemental source would be used during a drought or in case of emergency, and the quality during that period may be negatively impacted.

The reduction in fresh water flows caused by a drought or the increase in salt water flows caused by failure of islands during an earthquake would seriously degrade the quality of Delta water. **Chapter II states that flooding due to a moderate to strong earthquake could result in salinity or TDS levels in the range of 1,000 or 2,600 mg/L in the Delta near the Mokelumne Aqueducts. Use of such water, even if blended with EBMUD's terminal reservoirs, would require delivery of water near the short-term secondary drinking water standard of 1,500 mg/L. According to Title 22 of the California Administrative Code, TDS levels between 1,000 and 1,500 mg/L are "acceptable only for existing systems on a temporary basis pending construction of treatment facilities or development of acceptable new water sources."**

**Title 22 recommends a maximum TDS level of 500 mg/L for long term use, however, even though their Delta supply averages approximately 340 mg/L of TDS, a 1987 survey (Solem, 1987)**

indicates that about 40 percent of the people in the Contra Costa Water District use bottled water rather than the public water supply from the Delta because of its taste.

Pardee Reservoir has an average TDS level of approximately 40 mg/L and the terminal reservoir TDS levels range between 80 and 200 mg/L. If the salinity of EBMUD's supply increased to 1,000 to 1,500 mg/L, it could be expected that at least 25 percent of its customers would abandon the public supply for more expensive bottled water. Assuming only 25 percent of EBMUD's customers switched to bottled water for a year, the total added expenditure for bottled water would be approximately $30 million.

The average water bill for these households would more than triple. This would likely lead to a permanent use of bottled water by some customers, which would be inconsistent with EBMUD's duty to protect the public welfare by assuring a supply of pure, wholesome and potable water.

These high salinity levels would cause very high levels of THM's in drinking water supplies drawn from the Delta. Even during dry years such as 1988, without levee failures, water utilities are finding it difficult to meet THM standards when using Delta waters.

Under State Water Resources Control Board Decision 1485, the State Water Project and the Central Valley Project must be operated to meet designated water quality standards in the Delta. The standard for chlorides at Rock Slough, the supply for the Contra Costa Water District (CCWD), is 250 mg/L. However, salinities this high cause the formation of high levels of trihalomethanes. For example, in 1987 and 1988 when the chloride levels were 185 mg/L, THMs in the CCWD system were 84 ug/L. As the chlorides increase to 250 mg/L at Rock Slough, as expected in the Fall of 1988, it will be difficult to meet the 100 ug/L standard for THMs in CCWD's system. Some water utilities in Southern California are now preparing to notify the public of THM standard violations due to the poor quality of Delta water in 1988. EPA is expected to lower the THM standard of 100 ug/L substantially within the next few years.

The State Water Resources Control Board (SWRCB) recently denied a drought emergency request to pump Delta water to Camanche Reservoir to provide water for instream uses and crop irrigation downstream of Camanche Dam. The project would have allowed more high quality Mokelumne water to be stored in Pardee Reservoir to be used as drinking water for 1.1 million people. One of the reasons for the denial was the SWRCB's conclusion that the project would harm lawful users of the water. Specifically, the proposed project would have temporarily increased the trihalomethane levels (up to maximum levels of 1 to 5 ug/L) and sodium levels (from 8 to 70 mg/L in a few wells) in Lodi's groundwater drinking water supply. The SWRCB concluded that evidence presented was insufficient to show that the increased concentrations of these constituents would not harm Lodi residents.

It is also important to note that if the State declares an emergency due to drought or another problem, Delta water quality standards would no longer apply and would not have to be met.

### Conclusions

The public has indicated repeatedly in recent years that they are not willing to accept any risk from its drinking water and that they are willing to pay to improve water quality.

A 1981 survey (Muldavin, 1981) of residential water users in EBMUD's service area found that 63 percent of those responding would prefer to ration rather than use Delta water.

After the last drought the EBMUD Board of Directors appointed a Citizen's Advisory Committee to look at recommendations for EBMUD long-term water supply planning. This committee was composed of interested EBMUD customers, representatives of environmental organizations, representatives of civic organizations and local public officials. In 1985, the Citizen's Advisory Committee recommended against any diversions of Delta water to EBMUD's system.

This attitude is also exemplified by the passage of measures such as Proposition 65 and the high usage of bottled water statewide. Proposition 65 makes it illegal to discharge any substance known to cause cancer or birth defects into a drinking water source.

It can be concluded then that EBMUD's present policy of seeking sources of the highest quality for both normal use and use during emergencies should continue, and EBMUD should use Sierra sources only and avoid the use of Delta water. EBMUD should continue to pursue the use of advanced treatment technology to assure compliance with future drinking water regulations and to minimize the amount of chemicals required for water treatment.

## NEEDED IMPROVEMENTS

### Watershed Management and Improvement

EBMUD owns 26,000 acres of watershed land in the East Bay area. Of this, 8,000 acres is in water surface. In addition the East Bay Regional Park District and other public agencies own approximately 20,000 acres of open space contiguous to EBMUD's watershed lands. This is a permanent public asset which involves 80 miles of interconnected trails. Extensive treatment is provided for the water from San Pablo and Upper San Leandro Reservoirs which contain drainage from the Cities of Orinda and Moraga. The Briones Reservoir watershed is almost entirely in public ownership and the alternative terminal reservoir projects can be largely protected by public ownership.

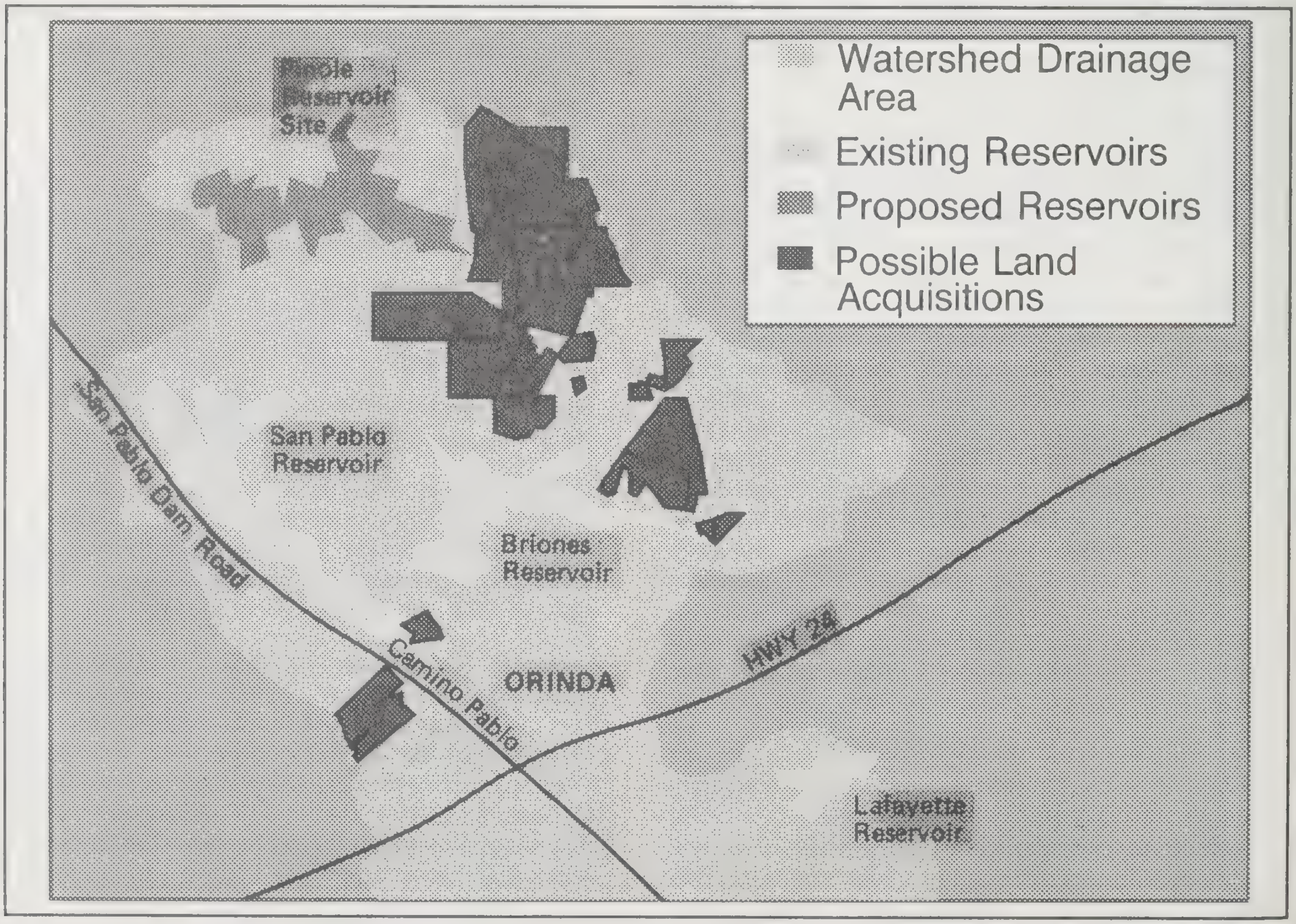
Watershed management is essential to providing high quality water to prevent sewage or other pollutants from entering reservoirs. This is threatened whenever development is proposed on adjacent watershed lands. EBMUD's ongoing watershed reconnaissance, water quality monitoring and land management activities will continue.

Watershed management would be improved by EBMUD's purchase of watershed lands currently in other ownership and which may have a potential for development. Acquisition of the land to the ridgelines around the terminal reservoirs to the extent possible would help assure that the high quality of stored water can be maintained into the future. The potential watershed land acquisitions under consideration are shown in Figures IV-11, IV-12 and IV-13. More detailed descriptions of these properties can be found in Appendix H.

The San Pablo watershed could benefit by acquisition of a total of 249 acres at an estimated cost of $1.9 million. The entire Briones watershed could be placed into public ownership with the purchase of 723 acres at an estimated cost of $4.8 million. The Upper San Leandro watershed could benefit by acquisition of 498

**EBMUD Watershed Improvements**
**Possible Land Acquisitions — North**

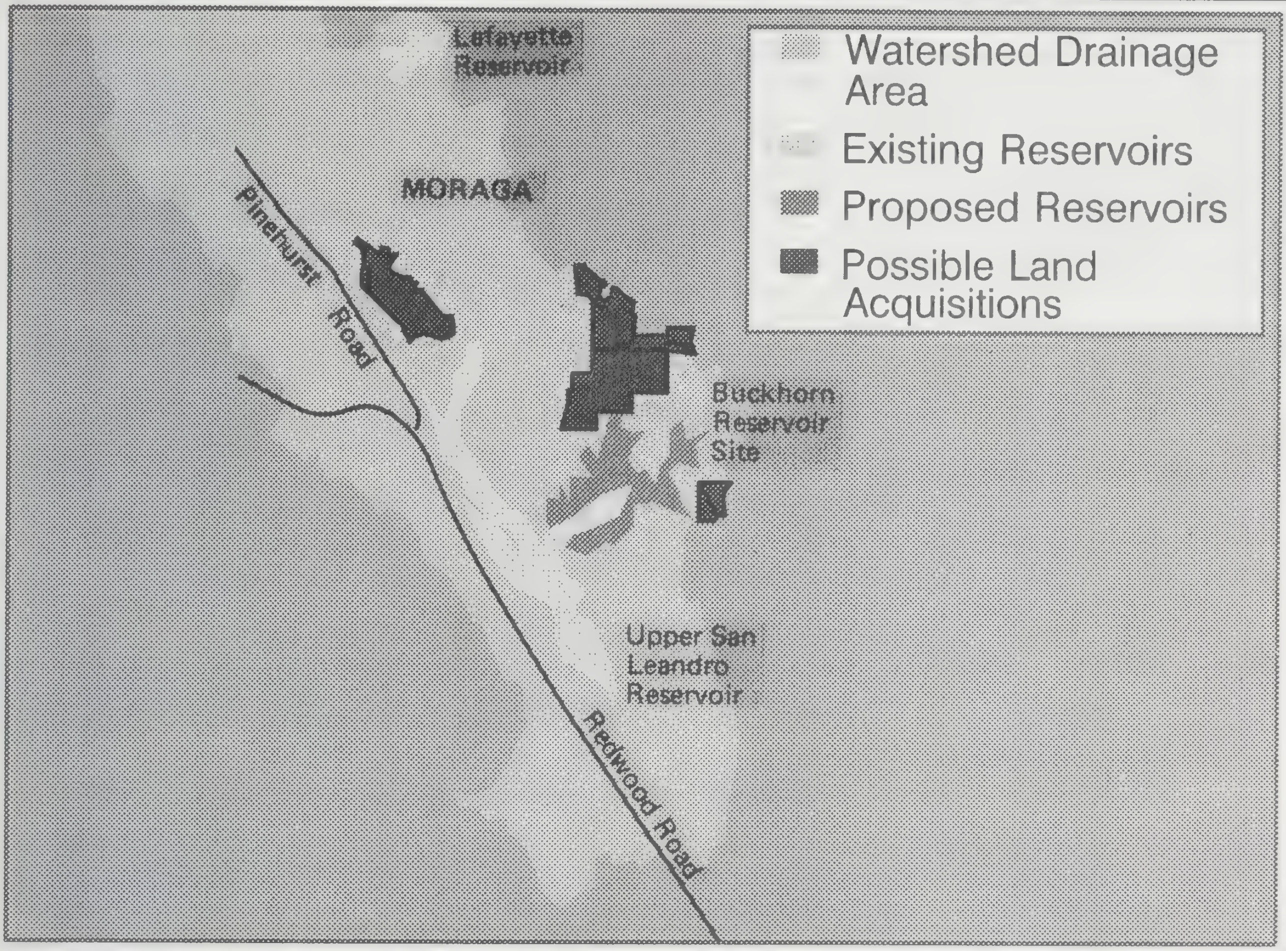
**Figure IV-11**



## EBMUD Watershed Improvements

**Possible Land Acquisitions — South**

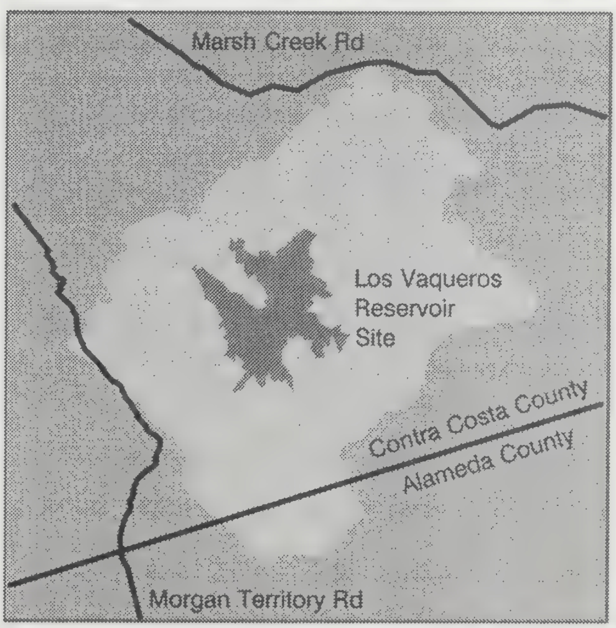
Figure IV-12




## EBMUD Watershed Improvements

**Possible Land Acquisitions — East**

Figure IV-13



## Treatment Improvement Program

Figure IV-14

| PROBLEM | SOLUTION |
|---|---|
| **TREATMENT PLANT MODERNIZATION — $18 MILLION** | |
| **Chemical Storage and Feed Control Improvements** | |
| The plants need improved storage of chemicals both in terms of quantity and adequacy of environment. The existing devices for chemical feed are outdated and manually controlled. | Improve existing chemical storage facilities for chlorine, sulfur dioxide, caustic soda, polymer and lime. Installation of raw water flow meters at Orinda and Lafayette.<br>Install chemical feed pumps that can be adjusted by a remote electronic signal. Install feed control equipment that will maintain chemical dosages as plant flowrates change. |
| **Water Quality Monitoring Improvements** | |
| On-line water quality monitors are outdated and limited in number. | Install turbidimeters for raw water and filtered water for all plants and all individual filters; pH meters on raw, filtered, and settled waters for all plants; and chlorine residual monitors for raw and treated water at all plants. |
| **Filter Operation Improvements** | |
| Filter operations are manually controlled and labor intensive. | Convert all existing pneumatic filter controls to electronic controls, replace all filter consoles and install programmable logic controllers to sequence backwash operations. |
| **Solids Disposal Improvements** | |
| Sedimentation basins require shutdown and draining for periodic cleaning. Plant capacity is thus reduced during this time. Solids accumulations can cause or contribute to taste and odor problems in the treated water. | Install continuous solids removal systems in the sedimentation basins of the full treatment plants and inmprove the existing solids disposal facilities at Lafayette, Orinda and Walnut Creek Filter Plants. |
| **General Plant Improvements** | |
| Emergency electrical supplies need expanded capacities to meet current plant operation requirements during power failures. | Install larger emergency generators, improve electrical equipment and make general improvements to the plant grounds. |
| **TASTE AND ODOR CONTROL: GAC AND OZONE — $17 MILLION** | |
| Seasonal algal blooms in the terminal reservoirs cause taste and odor at Sobrante and Upper San Leandro Filter Plants. | Install Granular Activated Carbon (GAC) to replace the existing sand filter media, and design and construct ozonation facilities at Sobrante and Upper San Leandro Filter Plants. |
| **COMPLIANCE WITH FUTURE REGULATIONS: OZONE** | |
| Improved methods in disinfection are likely to be required by impending drinking water regulations. Future regulations are likely to require the use of advanced treatment technology. | Perform pilot testing and preliminary design of ozonation facilities for Lafayette, Orinda and Walnut Creek Filter Plants. |
| **FUTURE TECHNOLOGY: MEMBRANE FILTRATION** | |
| An improved product with reduced chemical usage is a treatment objective. | Investigate the feasibility of the use of membrane filtration as a replacement for conventional treatment. |

acres at an estimated cost of $3.0 million plus the acquisition of the Buckhorn Reservoir watershed. The watershed around the Buckhorn Reservoir site could be entirely owned with the purchase of approximately 678 acres at an estimated cost of $2.5 million. The watershed around the Pinole Reservoir site would involve purchase of 24 parcels totaling 2,687 acres at an estimated cost of $16.1 million.

These acquisitions would also minimize ridgeline development in the Moraga/Orinda area and provide opportunities for significant trail enhancement.

## Treatment Improvements

Although EBMUD treated water is superior to state and federal standards, EBMUD continues to (1) modernize its treatment plants which range in age from 21 to 67 years, (2) improve its taste and odor control capabilities, (3) pursue advanced treatment technologies in anticipation of future drinking water regulations, and (4) evaluate future technologies. EBMUD is currently undertaking approximately $35 million in improvements as part of its ongoing treatment improvement program which is summarized in Figure IV-14.

### TREATMENT PLANT MODERNIZATION

Treatment plant modernization projects totalling approximately $18 million in improvements are now under design or construction.

These consist of upgrading chemical storage and feed systems to allow flow-pacing or residual feedback control of chemical feed. Also included are replacement of filter media, conversion of filter controls to provide automatic backwash sequencing, backwash water and solids handling facilities, and a system to allow computer control of plant processes. These improvements will be done at five of the six treatment plants (the sixth operates only during peak demand periods) and are scheduled for completion by 1994.

All of the improvements are designed to work well with the District's OP/NET system (a computer-based control system currently under construction for the water supply and distribution system). When completed, the improvements will result in higher water quality, lower chemical costs, less manual labor, less wastewater and lower solids handling costs.

### TASTE AND ODOR CONTROL: GAC AND OZONE

Replacement of the coal and sand filter media at the Sobrante and Upper San Leandro Filter Plants with granular activated carbon at a cost of approximately $2 million has started. To complement the granular activated carbon in the removal of taste and odors, pilot testing and design of ozone generation and feed facilities for the Sobrante and Upper San Leandro Filter Plants will start in 1988. A preliminary estimate of the cost of these ozonation facilities is $15 million. Ozonation facilities for Sobrante and Upper San Leandro Filter Plants are scheduled to be completed in 1990.

### COMPLIANCE WITH FUTURE REGULATIONS: OZONE

A proposed EPA rule on surface water treatment (SWTR) would require significant changes to EBMUD's water treatment processes, requiring the use of ozone instead of chlorine as the principal disinfectant. Pilot testing and preliminary design of ozone facilities for the Lafayette, Orinda, and Walnut Creek Filter Plants will start in 1988, which will determine the cost of retrofitting the filter plants.

Another important proposed rule is the Disinfection By-products Rule, which may reduce the MCL for THMs to as low as 10 ug/L. With the District's current method of disinfection, THMs cannot be reduced below 25 ug/L year-round.

The Disinfection By-products Rule will come into effect after the compliance date for the SWTR, meaning that important treatment improvement decisions regarding disinfection will already have been made. EPA has indicated that the only appropriate response by water utilities is careful, complete planning and reliance on generic, broad-spectrum treatment methods that will handle whole families of contaminants. System planning must take into account not only those regulations in effect, but all contaminants that will be regulated. Only the use of advanced treatment technology combined with highest quality sources will assure compliance with future drinking water regulations.

### FUTURE TECHNOLOGY: MEMBRANE FILTRATION

An extensive alternative treatment technologies evaluation is underway at EBMUD, designed to decrease chemical use while producing a higher quality product. One technology being considered is membrane filtration, which is thought to remove turbidity, bacteria, Giardia, and other particulates without the addition of coagulants. Reducing the use of chemicals is consistent with EBMUD's objective of keeping to a minimum the amount of chemicals introduced into the water treatment process.

# Chapter V
# Selection of Proposed Program

## OBJECTIVES

EBMUD's water supply problems and needs focus on three basic issues--security, shortage, and safety and health. These issues establish the objectives for development of the Water Supply Management Program:

- SECURITY: Provide security of the water supply against delivery system outages caused by floods and earthquakes.
- SHORTAGE: Provide an adequate water supply to meet dry year demands with limited water use restrictions.
- SAFETY AND HEALTH: Maintain high quality water.

Continuing from the problems and alternative solutions described in Chapters II, III, and IV, this chapter:

- Summarizes the alternatives for security, shortage, and safety and health and analyzes them as solutions for meeting the specific needs for improvement of the water supply system, to focus on the more-feasible alternatives;
- Evaluates the more-feasible alternatives in terms of a comprehensive program to meet water supply needs to the year 2020;
- Discusses the compatibility of the program alternatives with future decisions and the probable needs beyond 2020;
- Evaluates specific project site alternatives for implementing the program alternatives;
- Discusses the allocation of costs and financing; and
- Describes the proposed Water Supply Management Program.

## ANALYSIS OF SECURITY ALTERNATIVES

### Need for Improvements

The three Mokelumne Aqueduct pipelines cross the islands of the Sacramento-San Joaquin Delta for a distance of 16 miles, with 11 miles of the pipelines elevated above ground on pile supports and underwater crossings at three rivers. As described in Chapter II, these pipelines are vulnerable to severe damage and collapse due to major earthquakes and flooding. The potential outage of the Mokelumne supply for repair and reconstruction of the pipelines is 17 months in the event of a maximum earthquake on the Antioch fault in the western Delta. The more likely event (estimated frequency of once in 83 years) is an earthquake on one of 12 faults within 50 miles of the Delta with an outage of 13 months, which is assumed as a basis for planning purposes. The standby storage in EBMUD's five terminal reservoirs in the East Bay area is equal to only four to six months of water demand, which means that a severe rationing program to reduce demand by 70 percent would be required to survive a 13-month outage.

The security of the Mokelumne supply needs to be improved to:

- Assure that an adequate high quality supply is available to meet water demand, with rationing, during an extended outage; and

- Limit the severity of rationing during an extended outage.

The supply required for a 13-month outage of the Mokelumne system is shown in Figure V-1. The various alternatives considered in Chapter II for covering the supply deficiency and thus improving the security of the water supply system are listed in Figure V-2 with expanded detail given in Figure V-3.

## Do Nothing

To do nothing would mean a continuation of the problem with the need for severe water rationing during an extended outage. In the event of a disaster, EBMUD would not be prepared to minimize the adverse impact on EBMUD customers. Deterioration of the conditions in the Delta, particularly the levees, would over time mean increased vulnerability to damage and collapse of the pipelines with a worsening of the potential impact on EBMUD customers.

## Water Conservation

EBMUD's water conservation efforts began in the early 1970's and have continued with an increased emphasis in recent years. Rationing in 1977 and 1988 have provided first hand experience with customer reaction to a short-term water shortage emergency and the impacts of water use restrictions. It is reasonable to assume that an acceptable level of short-term water conservation through rationing would be required in the event of a disaster, and should be part of EBMUD's water supply planning.

The alternative of expanding EBMUD's water conservation program to keep water demand during normal conditions at a low enough level to survive an extended outage of the Mokelumne supply would have to be based on extreme mandatory measures. Demand is currently about 220 MGD and is projected to increase to 280 MGD in 2020 (see following section on shortage). The existing standby storage in the terminal reservoirs will accommodate a demand of only 82 MGD for 13 months, which would require reductions of 148 MGD today and 198 MGD in 2020 (see Figure V-1).

In Chapter III it was shown that continued implementation of the existing water conservation program would achieve a reduction of 4 MGD in 2020. Additional measures considered to be the most reasonable, feasible, and publicly acceptable would achieve an additional 2 MGD savings, for a total reduction of 6 MGD. The planning projection of 270 MGD for 2020 assumes the existing program and additional measures. Theoretical measures would have a potential for saving an additional 15 MGD by 2020 by getting into the realm of mandatory measures; however, these would be costly to customers and have unproven records. For example, mandatory replacement of toilets with ultra-low flush models by all residential customers could save about 13 MGD by 2020, but would cost several hundred dollars per home.

A permanent reduction of current demand to 82 MGD (63 percent reduction) would require extraordinary changes in water use by residential, industrial, commercial, institutional, and irrigation customers, with significant investment by customers in water saving equipment. There would be major impacts on the economy and lifestyle of the East Bay area. The experience with rationing during 1977 demonstrated what EBMUD customers had to do to achieve only a 39 percent reduction in demand—landscape irrigation was drastically reduced or eliminated, people flushed toilets and used showers less frequently, and non-essential water uses were suspended. Industrial and institutional customers became more efficient in their water use by installing new equipment, repairing leaks, and modifying processes, much of which continues today making further reductions in water use more difficult.

If the permanent reduction under normal conditions was less, for example a 35 percent reduction to a level of 143 MGD, the restrictions on water use would be similar to the rationing in 1977 but with long-term impacts on the economy and lifestyle. Then in the event of an extended outage, extreme measures would be necessary to further reduce demand to 82 MGD.

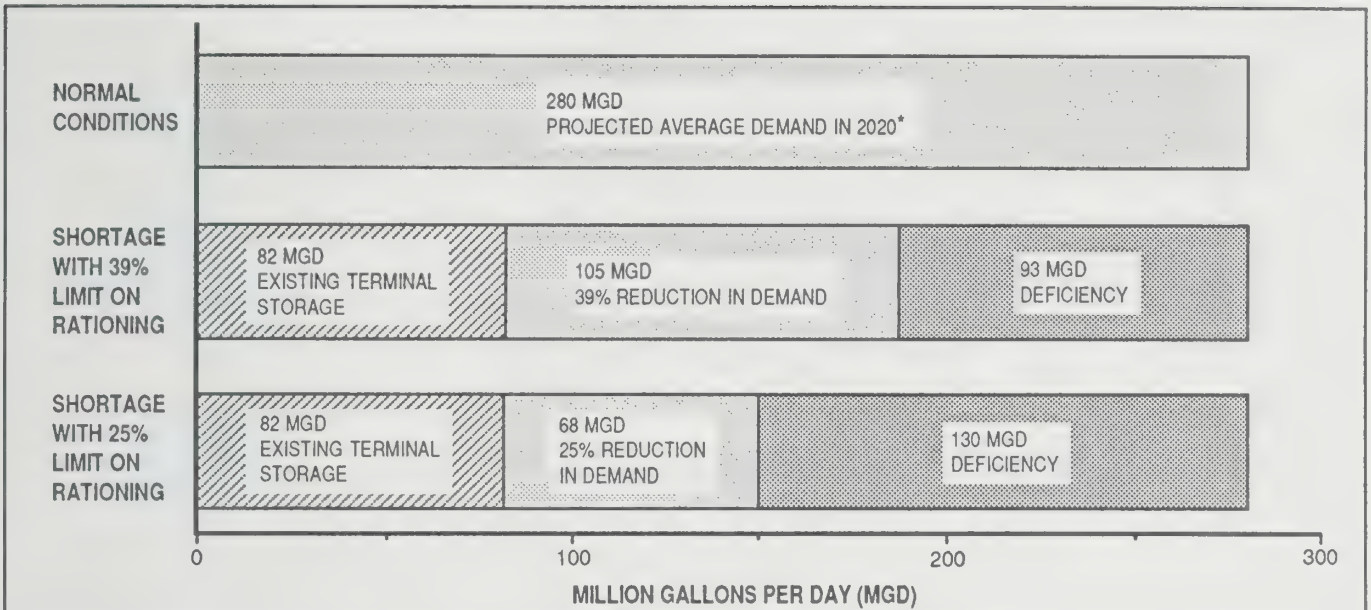
It is difficult to speculate on the reductions that would be assigned to the various categories of customers under such an approach. However, if the impact on the economy of the region were to be minimized then most of the burden for the 63 percent reduction would have to be borne by an even greater reduction in residential and irrigation water uses (together they account for about two-thirds of current demand).

As new development receives water service and demand increases, the extreme water conservation measures would have to become stricter to be able to survive a 13-month outage. The 63 percent would increase to a 70 percent reduction in 2020 to achieve a demand level of 82 MGD.

EBMUD's effort in 1987 to have customers voluntarily reduce demand by 12 percent during the last half of the year did not achieve that result, although it may have kept the demand from increasing more. Obviously, the intended results of a water conservation program are not always reliable and predictable. Public acceptance of the need to conserve and the conservation measures are important factors.

## Supply Required for 13-Month Outage

Figure V-1




*With no reductions for water conservation and reclamation. The planning projection is 270 MGD assuming continued implementation of the existing programs, upon which the 39% and 25% reductions in demand are based.

## Alternatives for Improving Security

Figure V-2

| | |
|---|---|
| 1. DO NOTHING | |
| 2. WATER CONSERVATION | 2.1 Continue existing program<br>2.2 Landscape and water management<br>2.3 Ultra low flow toilets and showers<br>2.4 Water-saving technology<br>2.5 Landscape rebate program |
| 3. WATER RECLAMATION | 3.1 Chevron refinery and Alameda golf courses projects<br>3.2 San Ramon Valley irrigation |
| 4. LEVEE IMPROVEMENTS IN THE DELTA | 4. Levee improvements in the Delta |
| 5. NEW AQUEDUCT ACROSS THE DELTA | 5.1 Limited capacity pipeline (one pipe)<br>5.2 Full capacity pipeline (two pipes) |
| 6. WATER BANKING (Additional Terminal Storage) | 6.1 Pinole Reservoir<br>6.2 Buckhorn Reservoir<br>6.3 Los Vaqueros Reservoir |
| 7. INTERTIES WITH OTHER AGENCIES | 7.1 Hayward treated water<br>7.2 Contra Costa Water District treated water<br>7.3 Hetch Hetchy untreated water<br>7.4 Alameda County Zone 7 treated water |
| 8. USE OF DELTA WATER | 8.1 No pretreatment<br>8.2 With pretreatment |

These alternatives are described in more detail in Figure V-3.

# Security Alternatives

| 1. DO NOTHING | 2. WATER CONSERVATION | | | | |
|---|---|---|---|---|---|
| | 2.1 Existing Program | 2.2 Landscape and Water Management | 2.3 Ultra Low Flow Toilets & Showers | 2.4 Water Saving Technology | 2.5 Landscape Rebate Program |
| **DESCRIPTION OF ALTERNATIVE** | | | | | |
| Continue present levels of existing water conservation (no further implementation) and water reclamation programs, current levels of levee maintenance, and no new projects. | Continue to Implement:<br>• Device distribution<br>• Water audits<br>• Landscape consultation<br>• Establish landscape water use efficiency guidelines | Additional measures:<br>• Expand consultations<br>• Audits for industries<br>• Irrigation management<br>• Pilot studies of landscape rebate<br>• Residential wellwater use | Support adoption of state law requiring ultra low flow fixtures in new construction. After, mandated for new construction, consider requiring replacement on resale or subsidy for existing customers. | For non-residential customers, require retrofit devices on sanitary fixtures and latest water saving technology for cooling water and industrial process water. | Provide monetary rebate to encourage customers to replace existing landscaping with low water landscaping. |
| **MEETS OBJECTIVES?** | | | | | |
| No. Continued problem of deficient supply in outages and droughts. | No. But would reduce demand by 4 MGD. | No. But would reduce demand by an additional 2 MGD. | No. But could reduce demand by an additional 2.1 and 12.8 MGD. | No. But could reduce demand by about 1.2 MGD. | No. But could reduce demand by about 1.3 MGD. |
| **COST** (Total EBMUD and Consumer Costs) | | | | | |
| ——— | $0.3 million per year | $0.5 million per year | Replacement program $10-13 million per year | $0.1 million per year plus consumer cost. | $0.1 million per year plus consumer cost. |
| **REMARKS** | | | | | |
| ——— | Current program also includes leak detection, pipeline rehabilitation, water metering, demonstration gardens, public information & school education. | These are feasible measures that can be implemented. | Emerging technology. Uncertain acceptance by existing customers because of high consumer cost for replacements. | May be difficult to administer. If cost effective technology exists, customers will use it without regulations. | Untested measure. Pilot program is included in Alternative 2.2. |

| 6. WATER BANKING - ADDITIONAL TERMINAL STORAGE | | | 7. INTERTIES WITH OTHER AGENCIES | | |
|---|---|---|---|---|---|
| 6.1 Pinole Reservoir | 6.2 Buckhorn Reservoir | 6.3 Los Vaqueros Reservoir | 7.1 Hayward Treated Water | 7.2 CCWD Treated Water | 7.3 Hetch Hetchy Untreated Water |
| **DESCRIPTION OF ALTERNATIVE** | | | | | |
| Construct terminal reservoir at EBMUD's Pinole site with 50,000 acre-feet of storage. Includes tunnel, pipeline, and pumping plant. | Construct terminal reservoir ar EBMUD's Buckhorn site:<br>• 100,000 acre-feet for 39% rationing.<br>• 145,000 acre-feet for 25% rationing.<br>Includes tunnel, pipeline, and pumps. | Participate in CCWD project ar the Los Vaqueros site:<br>• 108,000 acre-feet for 39% rationing.<br>• 155,000 acre-feet for 25 % rationing.<br>Includes tunnel, pipeline, and pumps. | Negotiate agreement with Hayward for use of existing interties (Hetch Hetchy water). | Negotiate agreement with CCWD and construct intertie at CCWD's Bollman treatment plant. | Negotiate agreement with San Francisco and construct interconnecting pipeline (27 miles) and pumping plant between Hetch Hetchy and Mokelumne Aqueducts. |
| **MEETS OBJECTIVES?** | | | | | |
| Partially, 36 MGD for 13 months. | Yes, 82-119 MGD for 13 months. | Yes, 82-119 MGD for 13 months. | Partially, 5-10 MGD. | Partially, 15 MGD seasonal. | Uncertain but may be about 30 MGD. |
| **COST** | | | | | |
| $65 million | 100,000 AF-$122 mil.<br>145,000 AF-$152 mil. | 108,000 AF-$150 mil.<br>155,000 AF-$186 mil. | None | $1 million | $100 million |
| **REMARKS** | | | | | |
| With 39% limit on rationing, would provide 5.8 months of supply. With 25% limit, 4 months/ Initial filling $3.8 million. | Size based on security needs. Cost of initial filling $11 million to $17 million. | Size based on security needs. Cost of initial filling $9 million to $13 million. | Not expected to be available in drought shortage. | Detailed investigation needed to develop project and availability. | Detailed investigation needed. May be short term. Not expected to be available in drought. |

Figure V-3

| 3. WATER RECLAMATION | | 4. LEVEE IMPROVEMENTS IN THE DELTA | 5. NEW AQUEDUCT ACROSS THE DELTA | |
|---|---|---|---|---|
| 3.1 Chevron and Alameda Projects | 3.2 San Ramon Valley Irrigation | | 5.1 Limited Capacity Pipeline | 5.2 Full Capacity Pipelines |
| **DESCRIPTION OF ALTERNATIVE** | | | | |
| Complete the Chevron refinery cooling water project in Richmond; develop and construct the Alameda Golf Courses irrigation project. | Develop and construct and irrigation project in the San Ramon Valley for golf courses and greenbelts. | Complete current levee repair and upgrading work and develop and implement a program of futher levee improvements. | Construct one 86" pipeline across the Delta designed to survive flooding and ground shaking due to an earthquake - 15 miles elevated; 3 river crossings. | Construct two 86" pipelines across the Delta designed to survive flooding and ground shaking due to an earthquake - 15 miles elevated; 3 river crossings. |
| **MEETS OBJECTIVES?** | | | | |
| No. But would reduce demand by 5.2 MGD. | No. But potential to reduce demand by about 1.4 MGD. | No. But increases security against levee failures. | Yes, up to 170 MGD. | Yes, up to 325 MGD. |
| **COST** (Total EBMUD and Consumer Costs) | | | | |
| $15.5 to 16.6 million | $1,000 per acre-foot | $8 million | $175 million (minimum) | $265 million (minimum) |
| **REMARKS** | | | | |
| Pilot study for Chevron has | Previous study showed project would not be economically feasible without more users. | Would not provide physical protection against ground shaking due to an earthquake. | Requires studies and field testing of design concepts. Would not provide additional supply in drought. | Requires studies and field testing of design concepts. Would not provide additional supply in drought. |

| | 8. USE OF DELTA WATER | | 9. OTHER SOURCES OF WATER | | 10. WATERSHED ENHANCEMENT |
|---|---|---|---|---|---|
| 7.4 Alameda County Zone 7 | 8.1 No Pretreatment | 8.2 With Pretreatment | 9.1 Exchange with Woodbridge | 9.2 Purchase Mokelumne Water | |
| **DESCRIPTION OF ALTERNATIVE** | | | | | |
| Negotiate agreement with Santa Clara Valley WD and Alameda County Zone 7 for treated Delta water. Pipeline and pumping plant required. | Complete the construction of Bixler Emergency Pumping Plant to be used in an unexpected emergency. | Construct pretreatment facilities for Delta source to remove turbidity, disinfect, and reduce THM potential. Construct desalinization to reduce TDS. | Negotiate agreement and construct facilities to supply Woodbridge districts with Delta water; in exchange receive up to 39,000 acre-feet of Mokelumne water. | Negotiate agreement for direct purchase of Mokelumne water from Woodbridge districts, or develop conjunctive use project to achieve same results. | Improve watershed management and protection of water quality by purchase of land to ridgelines around terminal reservoirs. (Approx. 3,500 acres). |
| **MEETS OBJECTIVES?** | | | | | |
| Uncertain, but may be 5-10 MGD. | No. Not acceptable to plan on using Delta water without adequate treatment. | Yes, with desalinization. | Not an alternative for security. | Not an alternative for security. | Not an alternative for security. |
| **COST** | | | | | |
| $10 million (approximate) | ——— | $200 to $545 million | $25 million | Not yet known. | $20 million |
| **REMARKS** | | | | | |
| Detailed investigation needed to develop project and availability. | State Health Department limits this to unforseen emergencies. Planned use requires treatment facilities. | Range of cost depends on treatment for THMs and method of brine disposal. | Would be interrupted by Delta disaster. | Would be interrupted by Delta disaster. | Acquisitions could minimize ridgeline development in Orinda/Moraga area and allow more trails. |

Water pricing has been investigated as a water conservation measure, but EBMUD experience and studies show that under normal water supply conditions it is not effective. For example, the 50 percent increase in water rates for water service to customers at higher elevations over the past five years has shown no reduction in water use. Furthermore, EBMUD is required by law to charge no more than the actual cost of providing water service. On the other hand, the 1977 and 1988 experiences with rationing have shown that the threat of severe financial penalties for excessive use coupled with the declaration of an emergency can be effective on a short-term basis.

Water use efficiency through conservation is an important element of water supply management; however, it is not a viable alternative for security of the EBMUD water supply against extended outages because the demand reduction needed (63 to 70 percent) would require extraordinary changes in water use by EBMUD customers that would be expensive, would adversely impact the economy and lifestyle, and are unlikely to be accepted by the public.

### Water Reclamation

The reuse of water through water reclamation is an option for non-potable water uses such as irrigation and industrial cooling. Feasible reclamation projects require a large non-potable demand in a limited area, close proximity to a wastewater source, and limited additional treatment requirements. In Chapter III it was shown that current reclamation projects save approximately 4.7 MGD, and additional projects would reduce demand by an additional 5 MGD. Future reclamation projects could provide some additional savings, but not in the range of the 148 to 198 MGD reduction necessary to be able to survive a 13-month outage of the Mokelumne supply (see water conservation discussion above). When water uses are transferred to reclaimed water as a source, then the burden of demand reduction during an outage has to shift to other customers.

Water reclamation, like water conservation, is an important element of water supply management because it increases the efficiency of water use; however, it cannot alone or in combination with water conservation be a viable alternative for security of the EBMUD water supply against extended outages.

### Levee Improvements in the Delta

As described in Chapter II, EBMUD participates in the maintenance, repair, and upgrading of levees to avoid deterioration of the conditions that could cause levee failure due to sloughing, erosion, or over-topping. From 1981 through 1987, EBMUD contributed $1.3 million to this reclamation district work, and its contribution for completing it would be about $2.0 million. This would maintain the existing level of risk of failure. However, it would not provide physical protection against levee failure due to ground shaking caused by an earthquake and the potential for an extended outage of the water supply system, because of the poor foundation conditions—the peat and sandy soils on which the levees were built—and the poor quality of levee construction. It is estimated that an additional $6 million would be spent to further upgrade and improve the levees.

If the levees could be adequately reinforced, the foundation conditions under the levees and aqueduct pipelines adequately improved, and the pipeline supports and piles reconstructed to resist very high levels of ground shaking due to a major earthquake, then the risk of extended outage of the water supply system would be substantially reduced. However, this is not feasible because such levee reinforcement and foundation improvement technology is only conceptual and unpredictable, and the cost of reconstructing the pipeline supports and piles would exceed that of building a separate new pipeline across the Delta (next alternative below).

Levee maintenance and repair in the Delta would be an important element of water supply management, but is not a viable alternative for security of the EBMUD water supply against extended outages.

### Foundation Studies in the Delta

There is preliminary engineering work that must be done before future improvements in the Delta can be made in preparation for a disaster:

- Investigation and feasibility studies of levee reinforcement and of modification of supports under the existing aqueduct pipelines for reducing the risk of aqueduct damage due to flooding and lower levels of ground shaking caused by earthquakes; and
- Field testing and preliminary design of possible pile support systems and a future aqueduct pipeline across the Delta to shorten the response time in the event of a disaster.

The cost of the investigation and feasibility studies is estimated at $0.5 million and the field testing of possible support systems is estimated at $1.5 million. The cost of preliminary design of a new pipeline depends on effort required, which cannot be determined until after the investigation, testing, and studies. While this preliminary engineering for

foundation improvements is not an alternative for security, it would be an effective part of EBMUD's water supply management.

### New Aqueduct Pipeline Across the Delta

Construction of a new pipeline or pipelines across or around the Delta could provide secure delivery of the Mokelumne supply. It would be designed to survive the estimated maximum ground shaking due to earthquake and long-term inundation if an island is flooded. Partial capacity would require one 86-inch pipeline, and full capacity would require two 86-inch pipelines. Studies indicate that the most cost-effective alignment is parallel to the existing aqueducts.

The pipe supports under the elevated pipe would be designed to withstand the maximum expected earthquake forces and to accommodate the liquefiable sandy foundation soils. The design would also take into account the effects of scour around pipe supports from the flow through a levee break. Field testing of possible pipe support and pile system designs and investigation of levee reinforcement at river crossings would be required. The estimated total project cost for one pipeline is $175 million and for two pipelines is $265 million.

The implementation of EBMUD's contract with the U. S. Bureau of Reclamation for delivery of supplemental water from the Folsom South Canal could affect the size of the pipeline. Because of the high cost of this alternative, the possibility of a delivery capacity above 325 MGD should be considered. This might require delaying design and construction until the legal obstacles related to the USBR contract are cleared.

### Water Banking--Additional Terminal Storage

In Chapter II it was shown that water banking can provide security against an extended outage of the Mokelumne supply. In this alternative, the standby capacity in EBMUD's five terminal reservoirs would be increased by the additional storage provided in a new terminal reservoir west of the Delta, in or near EBMUD's service area. The amount of storage needed depends on the extent of outage planned for, the level of normal demand, and the planned reduction in water use during the outage. As shown in Figure V-4, the more-likely 13-month outage would require 145,000 acre-feet of additional storage at the projected demand of 270 MGD in 2020 with a demand reduction of 25 percent by rationing during the outage. If the planned demand reduction is 39 percent (the reduction achieved by rationing in 1977), then 100,000 acre-feet of additional storage would be required.

Reservoir sites are available for the additional storage required and are discussed later in this chapter. The estimated cost of this alternative depends on the site and the size of the reservoir. The ranges of total project costs based on 270 MGD demand in 2020 are:

| Demand Reduction During Outage | Additional Storage Required (acre-feet) | Range of Estimated Project Costs ($ million) |
|---|---|---|
| 39% | 100,000 | 122 to 150 |
| 25% | 145,000 | 152 to 186 |

The operational cost of filling a new reservoir would range from $11 to $17 million, depending on the site and the size.

### Interties with Other Agencies

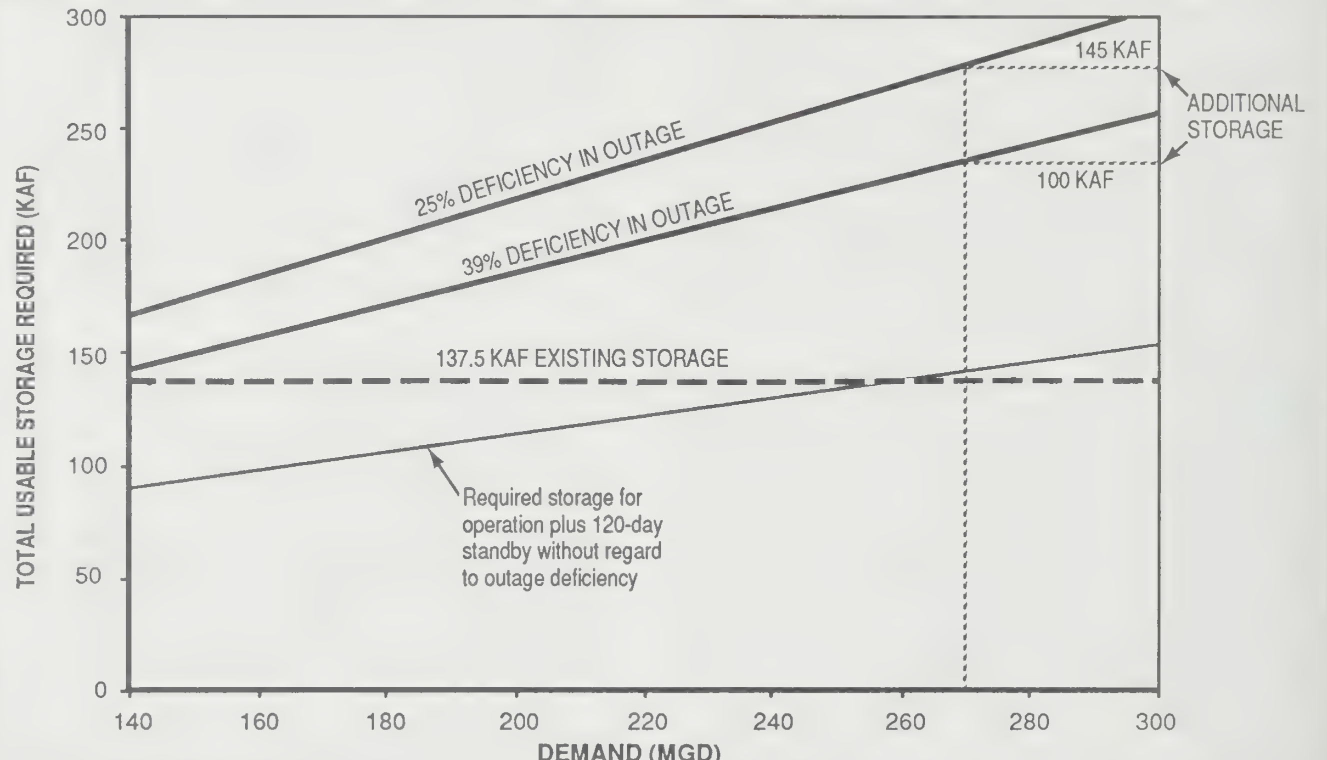
Adjacent and nearby water supply systems of other agencies offer the possibility of emergency supplies during an extended outage of the Mokelumne system. No utility has a significant long-term surplus that EBMUD can depend on for the required water quantity and outage time. In addition, water rights and environmental issues associated with any change in source or place of use could be significant. Nevertheless, intertie possibilities need to be considered.

San Francisco's Hetch Hetchy system could help in the event of a disaster in the Delta since it is not dependent on physical conditions in the Delta. The connection could be through the City of Hayward, with which EBMUD has emergency connections, or by constructing a major transmission pipeline between the Mokelumne Aqueducts and the Hetch Hetchy Aqueducts, from Walnut Creek south to Sunol in the Livermore Valley (27 miles) or from the Brentwood area south to a point in the Central Valley (25 miles). The water quality would be equal to that of the Mokelumne. The existing Hayward connections can deliver only 5 to 10 MGD, whereas a major transmission pipeline could deliver a significant quantity of water. Such a pipeline would cost approximately $100 million. Any interties with the Hetch Hetchy system might help in the event of a Mokelumne supply outage, if the water were available; but this would be an uncertainty.

The Contra Costa Water District system is supplied from the Delta under a contract with the U. S. Bureau of Reclamation and its own water rights. The system has no appreciable storage, but CCWD is planning the construction of Los Vaqueros Reservoir. A supply from the Delta through CCWD is not a viable source that EBMUD could depend on because

## Terminal Storage Needed for Security from 13-Month Aqueduct Outage

Figure V-4




2020 conditions on the Mokelumne River

the flooding of islands resulting from a disaster in the Delta would cause salt water intrusion from the Bay with extremely high salinity levels. If use of Delta water were feasible, then EBMUD could pump directly from the Delta. (See discussion of Delta alternative below.) **There is a possibility that a limited quantity, about 15 MGD, of treated water might be available on a seasonal basis from CCWD's Bollman Treatment Plant, but would be uncertain as to long-term availability. The pipeline and pumping plant required to deliver water from the treatment plant to the Mokelumne Aqueducts would cost about $1 million.**

The State Water Project pumps water from the southern Delta to Bethany Reservoir for the California Aqueduct and for the South Bay Aqueduct extending to southern Alameda County and Santa Clara County. As with the Hetch Hetchy source, a major transmission pipeline would be needed for a connection. It would have to be located between the EBMUD system and either Bethany Reservoir or the South Bay Aqueduct at a cost that may be on the order of $400 million for treatment facilities and a pipeline. The Delta diversion point would be further east than CCWD's, so the impact of salt water intrusion might be less depending on the type of disaster and the extent of flooding. Apart from the salinity problem, the quality of Delta water is inconsistent with the treatment systems at EBMUD's major filter plants and its water quality policy. As with the Hetch Hetchy source, a major transmission pipeline would be needed for connection. The State Water Project is not a source that EBMUD could depend on because of the uncertainty regarding salinity, the need for water treatment improvements, and the supply may not be available when needed.

**A consideration would be use of State Project water from the Santa Clara Valley Water District (SCVWD), which has several sources of supply, by wheeling it through the facilities and treatment plant of the Alameda County Flood Control and Water Conservation District Zone 7 in the Livermore Valley. The limited capacity for treatment in Zone 7 would restrict this option to only 5-10 MGD. A pipeline and pumping plant would be required, but feasibility is uncertain and a specific project has not yet been developed. The cost may be on the order of $10 million.**

Interties with other agencies are not a viable nor dependable alternative for solving EBMUD's security problem. However, they should be considered in EBMUD's water supply management. Studies can be

undertaken to increase the capacity of the existing connection with the Hetch Hetchy system through the City of Hayward and to further explore the feasibility of a direct intertie with the Hetch Hetchy system and of the use of treated water from CCWD..

### Delta Water Use

Water from the Delta is adequate in quantity, but its quality even under normal conditions is inconsistent with the treatment systems at EBMUD's major filter plants and its policy on water quality.

During the 1976-77 drought, EBMUD used Delta water mixed with existing supplies, with potentially adverse effects on the health of its customers. Significant taste and odor problems were experienced. The most serious concern was the increased level of trihalomethanes (THMs), which were caused in large part by elevated levels of bromide from sea water intrusion into the Delta. It took six years for the higher levels of THMs to be flushed out of EBMUD's terminal storage.

In the event of a Mokelumne supply outage caused by flooding or an earthquake disaster in the Delta, there would be no Mokelumne supply to blend with Delta water and EBMUD's major filter plants are not equipped to treat it. Furthermore, salt water intrusion from the Bay would cause extremely high levels of salinity which would make the water unusable. **To be able to plan on using Delta water during an extended outage of the Mokelumne supply would require construction of pretreatment and desalinization facilities at the source. Pretreatment would remove turbidity, disinfect, and reduce the THM formation potential. Such facilities would cost in the range of $200 to $370 million, depending on the additional facilities required at existing filter plants for reduction of the THM formation potential. Desalinization would involve reverse osmosis treatment to reduce the elevated levels of total dissolved solids because of the extremely high salinity expected. Such facilities would be an additional cost in the range of $125 to $175 million, depending on the method of brine disposal. The brine might be pumped by pipeline to San Francisco Bay. The total cost of facilities for use of Delta water would be in the range of $325 to $545 million. This treatment would not necessarily eliminate the long-term health risks related to use of Delta water.**

Since its inception, EBMUD has maintained a policy of diverting no water from the Delta for delivery to customers (with the 1977 emergency an exception). EBMUD's Citizens Advisory Committee in 1985 recommended against such diversions, and state and federal policy urges providing water from the highest quality source. The use of Delta water is not a reasonable alternative for the needed security improvements.

### Groundwater Resources

There are no groundwater resources of appreciable size located within EBMUD. The potential yield is about 1 to 2 MGD with very poor water quality so this is not a reasonable alternative for needed security improvements.

### Other Sources

**Other sources that would be considered for needed drought shortage improvements, such as exchange of water with the Woodbridge districts and purchase of water from other users on the Mokelumne River, are not applicable to the security problem because those supplies would experience the same extended outage as the present Mokelumne supply.**

#### Conclusions Regarding Security Alternatives

From the above analysis of security alternatives, the most feasible and cost-effective approach to solving the security problem is water banking with the construction of additional terminal storage. Also, it offers the possibility of being a multi-purpose solution (see next section on shortage). Capacity should be based on the more-likely 13-month outage and a projected demand of 270 MGD in 2020, which is the mid-range growth rate and assumes full implementation of current water conservation and reclamation programs. A 25 percent demand reduction during outage should be part of the planning to reduce the severity of rationing and accommodate increased efficiency of water use. The amount of the additional terminal storage would be 145,000 acre-feet. The estimated cost would be $152 to $186 million, depending on the site selected (later in this chapter).

Construction of a new aqueduct across the Delta, parallel to the existing aqueducts, could provide the needed security of the water supply system against outages. The estimated total project cost for one pipeline to deliver 170 MGD is $175 million and two pipelines to deliver the 325 MGD Mokelumne system capacity is $265 million. This would be a single purpose solution. Field testing of design concepts for pipeline supports and levee reinforcement would be required prior to design and construction, and the results could increase the estimated cost. Also, the desirable design capacity could be affected by future implementation of the American River supply under the USBR contract.

Water conservation cannot provide security without a permanent extraordinary reduction in demand by imposing extreme mandatory conservation measures, with significant impacts on the economy and lifestyle of the East Bay area. The cost of water banking would be about $10 per year per household; the cost of water demand reduction and the related lifestyle impacts would cost the customer that much or more.

The Delta could provide an adequate quantity of water, but its quality under normal conditions is inconsistent with EBMUD treatment systems and policy on water quality. In the event of a disaster in the Delta, salt water intrusion would cause extremely high levels of salinity to make the water unusable and there would be no Mokelumne water for blending. The treatment facilities required would cost in the range of $325 to $545 million.

Other options would not be solutions to the security problem, but would provide benefits and should be pursued as part of a balanced water supply management program: Additional water conservation measures and water reclamation projects to continue to improve water use efficiency; continue levee repair and maintenance to offset the deteriorating conditions in the Delta; perform technical studies (preliminary engineering) of levee and foundation improvements in the Delta to find ways of reducing the risks of outage; and conduct studies of intertie improvements with other agencies.

## ANALYSIS OF SHORTAGE ALTERNATIVES

### Need for Improvements

EBMUD has the water rights and system capacity to divert up to 325 MGD from the Mokelumne River and deliver it to its customers, a quantity that is available in most years. The exception is drought periods of two or more extremely dry years when the supply from the Mokelumne is substantially reduced. In a repeat of precipitation and runoff conditions like 1976-77, the Mokelumne supply in conjunction with existing storage would be only 215 MGD, which is the firm yield. The firm yield is projected to decline to 198 MGD by 2020 as higher priority water users upstream of Pardee Reservoir increase their diversions.

Chapter III shows that the current demand of about 220 MGD is projected to increase to a level between 247 and 294 MGD in 2020, depending on the actual rate of new development and the effectiveness of water conservation and reclamation programs. The projected demand for a mid-range growth rate plus a variance of 10 MGD for weather and other conditions is 280 MGD. For planning purposes a projection of 270 MGD is being used, which assumes a water savings of about 10 MGD for full implementation of the current and additional water conservation and reclamation programs. As a utility, EBMUD has an obligation to provide water service to new development planned and approved by the 20 cities and two counties within its boundary and to annexations within its ultimate boundary. Service beyond the ultimate boundary is not included in the projected demand except for the Crow Canyon Road Extension Corridor area, most of which was recently annexed to EBMUD.

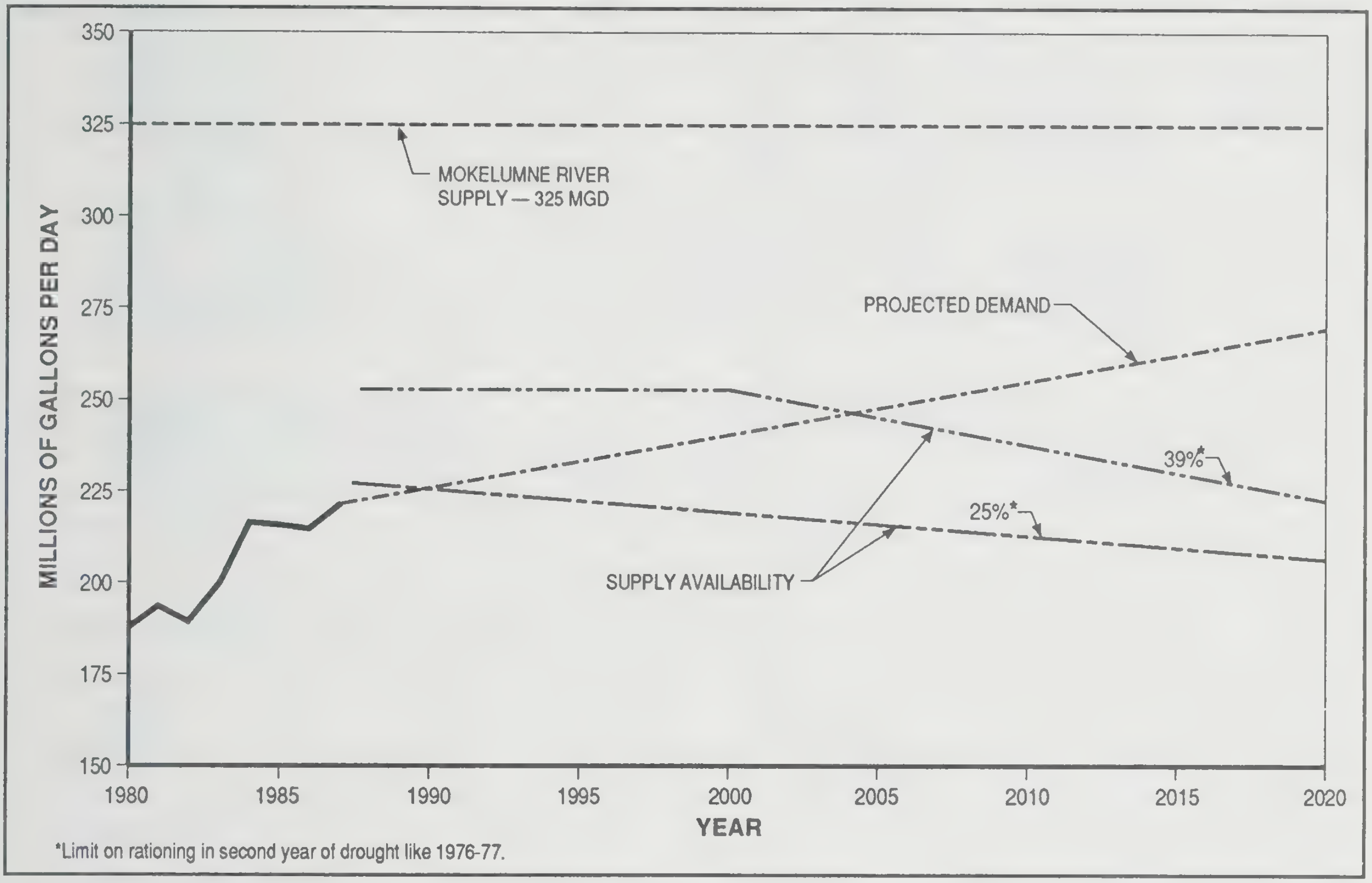
The projections show that water demand will be greater than the supply available in a drought period like a repeat of 1976-77. The effect will be a water shortage beginning in the second year. The ability to meet demand during the second year is based on a balance between the amount of water available from the Mokelumne River and other sources, the extent to which demand is reduced by a rationing program, and the amount of terminal storage available.

EBMUD responded to this problem by adopting in 1985 a Water Supply Availability and Deficiency Policy that includes water use restrictions during drought periods as part of EBMUD's water supply planning, but limits rationing to the same 39 percent reduction in demand achieved in 1977. EBMUD's water supply system currently has the capacity to meet demand in a repeat of 1976-77 drought conditions with a 39 percent reduction in the second year, but only until demand in normal years reaches about 240 MGD around the year 2000, as shown in Figure V-5.

The 39 percent reduction in demand in 1977 had a significant impact on EBMUD customers--the loss in landscaping alone was estimated at $75 million ($ 1977). That demand reduction would cause greater hardship and cost to customers today because the efficiency of water use has improved, particularly by industrial and institutional customers. It is estimated that the 1977 rationing program would produce a 35 percent reduction today, and that percentage will decline further as water conservation continues to improve water use efficiency. Lowering the limit on rationing to a level such as 25 percent would reduce the severity and accommodate improved water use efficiency. However, the existing water supply system does not have the capacity to meet demand in a drought period with only a 25 percent reduction in demand.

## Supply Availability of the Existing Water Supply System

Figure V-5




EBMUD's water supply system needs to be improved to:

- Provide an adequate supply of high quality water, with rationing, during drought periods when there is a water shortage; and
- Reduce the severity of rationing during a water shortage.

The supply required for the second year of a two-year drought like 1976-77 is shown in Figure V-6. The various alternatives considered in Chapter III for covering the supply deficiency and thus solving the problem of water shortages are listed in Figure V-7 with expanded detail given in Figure V-8.

### Do Nothing

To do nothing would mean a continuation of the problem of water shortages with an increasing severity of rationing as demand increases in the future. When demand exceeds about 240 MGD around the year 2000, the necessary percentage reduction in demand will be greater than the 39 percent achieved in 1977, as shown in Figure V-5.

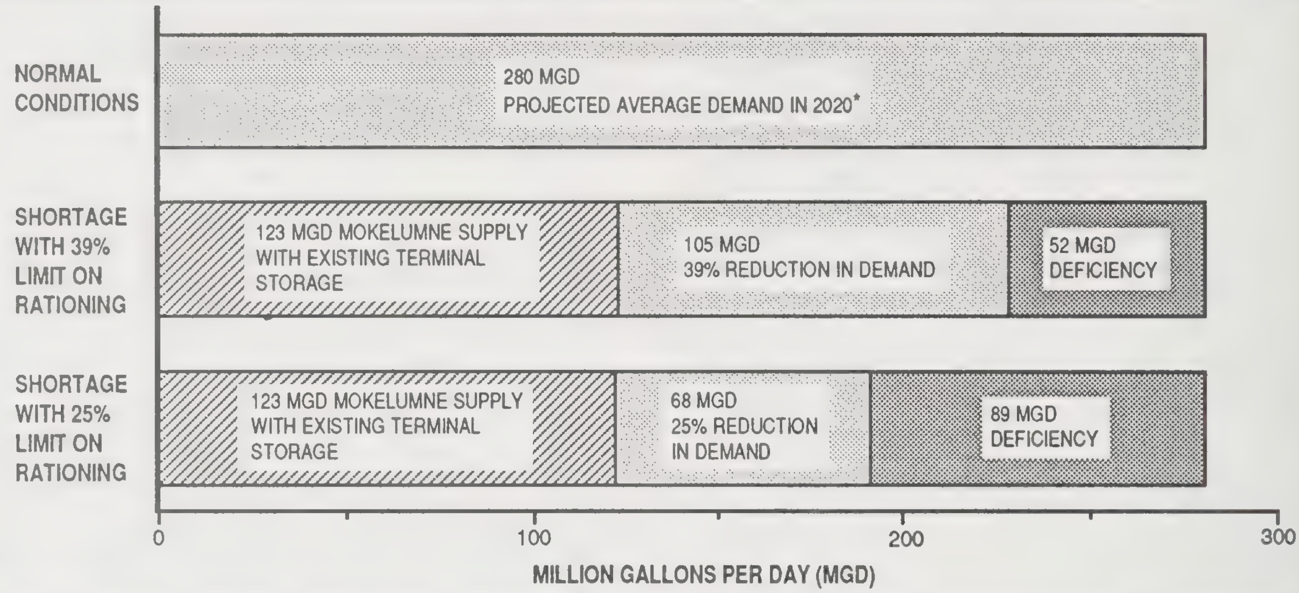
### Water Conservation

As pointed out in the security section of this chapter, water conservation efforts began in the early 1970's and have continued with increased emphasis in recent years. Rationing in 1977 and 1988 have provided first hand experience with customer reaction to a short-term water shortage emergency and the impacts of water use restrictions. It is reasonable to assume that an acceptable level of short-term water conservation through water rationing would be required in the event of a water shortage, and should be part of EBMUD's water supply planning.

The alternative of expanding EBMUD's water conservation program to keep water demand down during normal conditions at a low enough level to survive a period of water supply shortage in a drought would require unusual mandatory measures. Demand is projected to increase from the current 220 MGD to 280 MGD in 2020 and the firm yield of the Mokelumne system (with no deficiencies during drought) is projected to decline from 215 MGD to 198 MGD at the same time. To keep demand from exceeding the firm yield would require permanent reductions of 5 MGD today, about 31 MGD (13 percent) in 2000, and 82 MGD (29 percent) in 2020.

## Supply Required for Second Year of Drought

Figure V-6




*With no reductions for water conservation and reclamation. The planning projection is 270 MGD assuming continued implementation of the existing programs, upon which 39% and 25% reductions are based.

## Alternatives to Reduce Water Shortages

Figure V-7

| | |
|---|---|
| 1. DO NOTHING | |
| 2. WATER CONSERVATION | 2.1 Continue existing program<br>2.2 Landscape and water management<br>2.3 Ultra low flow toilets and showers<br>2.4 Water-saving technology<br>2.5 Landscape rebate program |
| 3. WATER RECLAMATION | 3.1 Chevron refinery and Alameda golf courses projects<br>3.2 San Ramon Valley irrigation |
| 4. LEVEE IMPROVEMENTS IN THE DELTA | Not applicable to the problem of drought shortage |
| 5. NEW AQUEDUCT ACROSS THE DELTA | Not applicable to the problem of drought shortage |
| 6. WATER BANKING (Additional Terminal Storage) | 6.1 Pinole Reservoir<br>6.2 Buckhorn Reservoir<br>6.3 Los Vaqueros Reservoir |
| 7. INTERTIES WITH OTHER AGENCIES | 7.1 Hayward treated water<br>7.2 Contra Costa Water District treated water<br>7.3 Hetch Hetchy untreated water<br>7.4 Alameda County Zone 7 treated water |
| 8. USE OF DELTA WATER | 8.1 No pretreatment<br>8.2 With pretreatment |
| 9. OTHER SOURCES OF WATER | 9.1 Exchange with Woodbridge Irrigation District<br>9.2 Purchase of additional Mokelumne River water |

These alternatives are described in more detail in Figure V-8.

In Chapter III and in the security discussion earlier in this chapter it was shown that continued implementation of the existing water conservation program and additional measures would achieve a reduction of 6 MGD by 2020. Theoretical measures would have the potential for saving an additional 15 MGD by 2020 by getting into the realm of mandatory requirements.

The permanent reductions necessary to keep demand from exceeding the firm yield would be greater than the potential 6 MGD or even an additional 15 MGD savings, and thus would require significant changes in water use by residential, industrial, commercial, institutional, and irrigation customers, with major investment by customers in water saving equipment and impacts on the economy and lifestyle of the East Bay area. Such permanent reductions in demand would make it very difficult to further reduce the demand in the event there are more than two extremely dry years in sequence during a drought. Because EBMUD's Mokelumne supply is more than adequate in most years, the benefits of such a strict full-time water conservation program would occur only in the occasional periods of shortage.

EBMUD's effort in 1987 to have customers voluntarily reduce demand by 12 percent during the last half of the year did not achieve that result, although it may have kept demand from increasing more. Obviously, the intended results of a water conservation program are not always reliable and predictable. Public acceptance of the need to conserve and the conservation measures are important factors.

As explained in the security discussion, EBMUD experience and studies show that water pricing is not effective as a means of reducing normal year demand. On the other hand, the 1977 and 1988 experiences with water rationing have shown that the threat of severe financial penalties for excessive use coupled with the declaration of an emergency can be effective on a short-term basis.

Water use efficiency through conservation is an important element of water supply management; however, it is not a viable alternative for the solution to water shortages during periods of drought because the permanent demand reduction needed in normal years (29 percent reduction by 2020) would require significant mandatory changes in regular water use by EBMUD customers that would be expensive, would adversely impact the economy and lifestyle, and are unlikely to be accepted by the public.

### Water Reclamation

As discussed in the security section earlier in this chapter, the potential for additional water reclamation projects is limited and would reduce demand by only 5 MGD. Water reclamation would not provide the reduction in normal demand of up to 82 MGD needed in 2020 to be able to survive a water shortage. Another consideration is that when water users are transferred to reclaimed water as a source, then the burden of demand reduction during a shortage has to shift to other customers.

Water reclamation, like conservation, is an important element of water supply management because it increases the efficiency of water use; however, it cannot alone or in combination with water conservation be a viable alternative for the solution to water shortages during periods of drought.

### Water Banking—Additional Terminal Storage

In Chapter III it was shown that water banking can provide the adequate supply needed to survive a repeat of a drought like 1976-77 and to reduce the severity of rationing. In this alternative, the standby capacity in EBMUD's five terminal reservoirs would be increased by the additional storage provided in a new terminal reservoir. The amount of storage needed depends on the level of normal demand and the planned reduction in water use during the shortage. As shown in Figure V-9, a repeat of 1976-77 drought conditions would require 95,000 acre-feet of additional storage for the projected demand of 270 MGD in 2020 with a demand reduction of 25 percent during the second year. If the planned reduction is 39 percent (the reduction achieved by rationing in 1977), then 55,000 acre-feet of additional storage would be required.

Reservoir sites are available for the additional storage required and are discussed later in this chapter. The estimated cost of this alternative depends on the site and size of the reservoir. The ranges of total project costs are:

| Demand Reduction During Outage | Additional Storage Required (acre-feet) | Range of Estimated Project Costs ($ million) |
|---|---|---|
| 39% | 55,000 | 86 to 112 |
| 25% | 95,000 | 115 to 146 |

The operational cost of filling a new reservoir would range from $6 to $11 million, depending on the site and size.

### Interties with Other Agencies

The potential for interties with adjacent and nearby water supply systems of other agencies is discussed earlier in this chapter under security alternatives.

# Shortage Alternatives

| 1. DO NOTHING | 2. WATER CONSERVATION | | | | |
|---|---|---|---|---|---|
| | 2.1 Existing Program | 2.2 Landscape and Water Management | 2.3 Ultra Low Flow Toilets & Showers | 2.4 Water Saving Technology | 2.5 Landscape Rebate Program |
| DESCRIPTION OF ALTERNATIVE | | | | | |
| Continue present levels of existing water conservation (no further implementation) and water reclamation programs, current levels of levee maintenance, and no new projects. | Continue to Implement:<br>• Device distribution<br>• Water audits<br>• Landscape consultation<br>• Establish landscape water use efficiency guidelines | Additional measures:<br>• Expand consultations<br>• Audits for industries<br>• Irrigation management<br>• Pilot studies of landscape rebate<br>• Residential wellwater use | Support adoption of state law requiring ultra low flow fixtures in new construction. After, mandated for new construction, consider requiring replacement on resale or subsidy for existing customers. | For non-residential customers, require retrofit devices on sanitary fixtures and latest water saving technology for cooling water and industrial process water. | Provide monetary rebate to encourage customers to replace existing landscaping with low water landscaping. |
| MEETS OBJECTIVES? | | | | | |
| No. Continued problem of deficient supply in outages and droughts. | No. But would reduce demand by 4 MGD. | No. But would reduce demand by an additional 2 MGD. | No. But could reduce demand by an additional 2.1 and 12.8 MGD. | No. But could reduce demand by about 1.2 MGD. | No. But could reduce demand by about 1.3 MGD. |
| COST (Total EBMUD and Consumer Costs) | | | | | |
| ——— | $0.3 million per year | $0.5 million per year | Replacement program $10-13 million per year | $0.1 million per year plus consumer cost. | $0.1 million per year plus consumer cost. |
| REMARKS | | | | | |
| ——— | Current program also includes leak detection, pipeline rehabilitation, water metering, demonstration gardens, public information & school education. | These are feasible measures that can be implemented. | Emerging technology. Uncertain acceptance by existing customers because of high consumer cost for replacements. | May be difficult to administer. If cost effective technology exists, customers will use it without regulations. | Untested measure. Pilot program is included in Alternative 2.2. |

| 6. WATER BANKING - ADDITIONAL TERMINAL STORAGE | | | 7. INTERTIES WITH OTHER AGENCIES | | |
|---|---|---|---|---|---|
| 6.1 Pinole Reservoir | 6.2 Buckhorn Reservoir | 6.3 Los Vaqueros Reservoir | 7.1 Hayward Treated Water | 7.2 CCWD Treated Water | 7.3 Hetch Hetchy Untreated Water |
| DESCRIPTION OF ALTERNATIVE | | | | | |
| Construct terminal reservoir at EBMUD's Pinole site with 50,000 acre-feet of storage. Includes tunnel, pipeline, and pumping plant. | Construct terminal reservoir ar EBMUD's Buckhorn site:<br>• 55,000 acre-feet for 39% rationing.<br>• 95,000 acre-feet for 25% rationing.<br>Includes tunnel, pipeline, and pumps. | Participate in CCWD project ar the Los Vaqueros site:<br>• 60,000 acre-feet for 39% rationing.<br>• 103,000 acre-feet for 25 % rationing.<br>Includes tunnel, pipeline, and pumps. | Negotiate agreement with Hayward for use of existing interties (Hetch Hetchy water). | Negotiate agreement with CCWD and construct intertie at CCWD's Bollman treatment plant. | Negotiate agreement with San Francisco and construct interconnecting pipeline (27 miles) and pumping plant between Hetch Hetchy and Mokelumne Aqueducts. |
| MEETS OBJECTIVES? | | | | | |
| Partially, 39 MGD for 12 months. | Yes, 41- 78 MGD for 12 months. | Yes, 41-78 MGD for 12 months. | No. | Partially, 15 MGD seasonal. | No. |
| COST | | | | | |
| $65 million | 55,000 AF: $75 mil.<br>95,000 AF: $120 mil. | 60,000 AF: $90 mil.<br>103,000 AF: $145 mil. | None | $1 million | $100 million |
| REMARKS | | | | | |
| With 39% limit on rationing, would provide 5.8 months of supply. With 25% limit, 4 months. Cost of initial filling $4 million. | Size of reservoir based on security needs. Cost of initial filling $6 million to $11 million. | Size of reservoir based on security needs. Cost of initial filling $5 million to $9 million. | Not expected to be available in drought shortage. | Detailed investigation needed to develop project and availability.Uncertain availability in drought. | Not expected to be available in drought. |

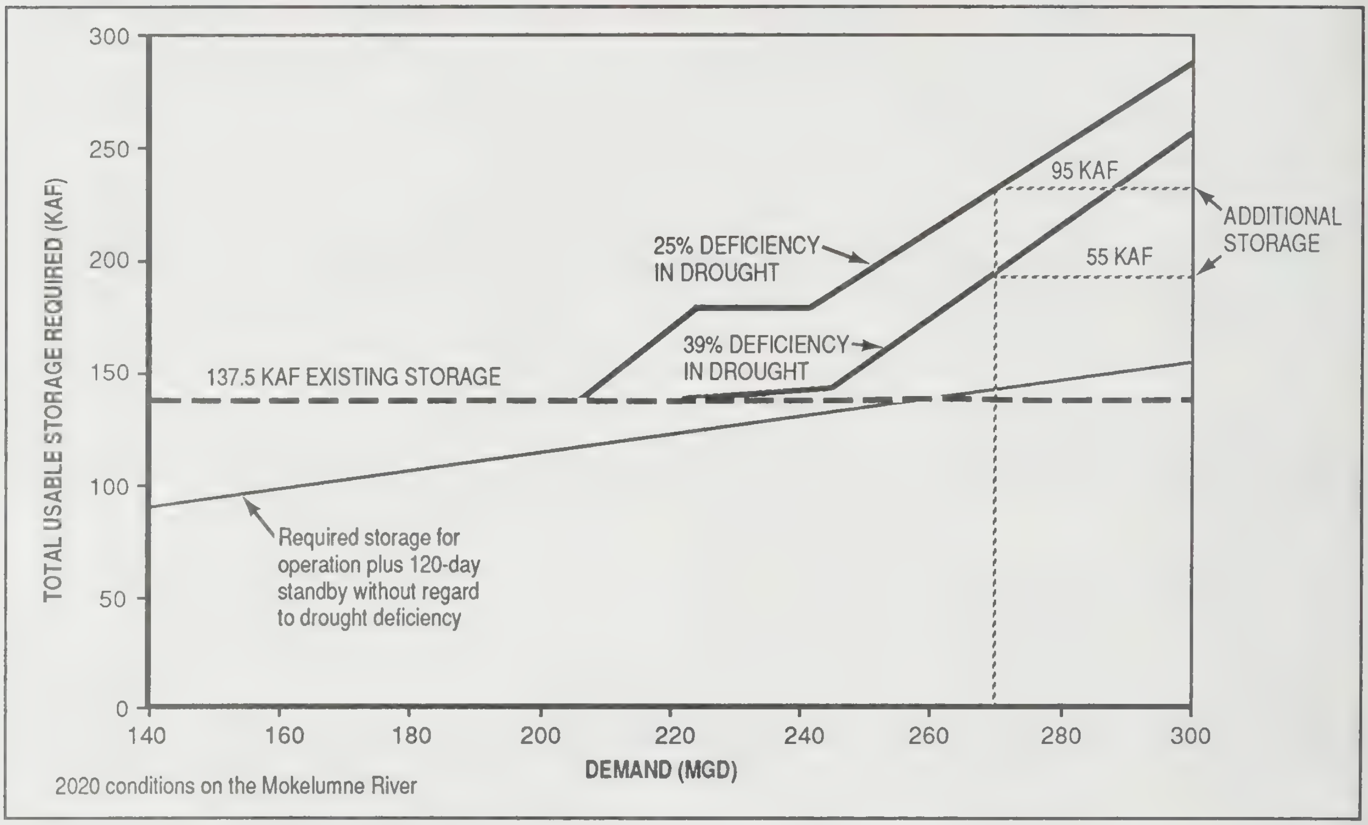
Figure V-8

| | 3. WATER RECLAMATION | | 4. LEVEE IMPROVEMENTS IN THE DELTA | 5. NEW AQUEDUCT ACROSS THE DELTA | |
|---|---|---|---|---|---|
| | 3.1 Chevron and Alameda Projects | 3.2 San Ramon Valley Irrigation | | 5.1 Limited Capacity Pipeline | 5.2 Full Capacity Pipelines |
| DESCRIPTION OF ALTERNATIVE | | | | | |
| | Complete the Chevron refinery cooling water project in Richmond; develop and construct the Alameda Golf Courses irrigation project. | Develop and construct and irrigation project in the San Ramon Valley for golf courses and greenbelts. | Complete current levee repair and upgrading work and develop and implement a program of futher levee improvements. | Construct 86" pipeline across the Delta designed to survive flooding and ground shaking due to an earthquake - 15 miles elevated; 3 river crossings. | Construct two 86" pipelines across the Delta designed to survive flooding and ground shaking due to an earth-quake - 15 miles elevated; 3 river crossings. |
| MEETS OBJECTIVES? | | | | | |
| | No. But would reduce demand by 5.2 MGD. | No. But potential to reduce demand by about 1.4 MGD. | Not an alternative for shortage. | Not an alternative for shortage. | Not an alternative for shortage. |
| COST (Total EBMUD and Consumer Costs) | | | | | |
| | $15.5 to 16.6 million | $1,000 per acre-foot. | —— | —— | —— |
| REMARKS | | | | | |
| | Pilot study for Chevron has been completed. | Previous study showed project would not be economically feasible without more users. | Would not provide any additional supply during drought shortage. | Would not provide any additional supply during drought shortage. | Would not provide any additional supply during drought shortage. |

| | | 8. USE OF DELTA WATER | | 9. OTHER SOURCES OF WATER | | 10. WATERSHED ENHANCEMENT |
|---|---|---|---|---|---|---|
| | 7.4 Alameda County Zone 7 | 8.1 No Pretreatment | 8.2 With Pretreatment | 9.1 Exchange with Woodbridge | 9.2 Purchase Mokelumne Water | |
| DESCRIPTION OF ALTERNATIVE | | | | | | |
| | Negotiate agreement with Santa Clara Valley WD and Alameda County Zone 7 for treated Delta water. Pipeline and pumping plant required. | Complete the construction of Bixler Emergency Pumping Plant to be used in an unexpected emergency. | Construct pretreatment facilities for Delta source to remove turbidity, disinfect, and reduce THM potential. | Negotiate agreement and construct facilities to supply Woodbridge districts with Delta water; in exchange receive up to 39,000 acre-feet of Mokelumne water. | Negotiate agreement for direct purchase of Mokelumne water from Woodbridge districts, or develop conjunctive use project to achieve same results. | Improve watershed management and protection of water quality by purchase of land to ridgelines around terminal reservoirs. (Approx. 3,500 acres). |
| MEETS OBJECTIVES? | | | | | | |
| | Security - uncertain, but may be 5-10 MGD. Shortage - uncertain, but may be 5-10 MGD. | No. Not acceptable to plan on using Delta water without adequate treatment. | Security - yes, with desalinization. Shortage - yes. | Partially, up to 35 MGD. | Partially. | Not an alternative for shortages. |
| COST | | | | | | |
| | $10 million (approximate) | —— | $200 to $370 million | $25 million | Not yet known. | —— |
| REMARKS | | | | | | |
| | Detailed investigation needed to develop project and availability. | State Health Department limits this to unforseen emergencies. Planned use requires treatment facilities. | Range of cost depends on treatment for THMs. Long term health risks are a concern. | EBMUD's attempt to exchange water has not been successful. Discussions are continuing. Reduced flows in the Mokelumne River would be a concern. | EBMUD's attempts to purchase water have not been successful. Discussions continue regarding conjunctive use. Reduced flows in the Mokelumne River would be a concern. | Acquisitions could minimize ridgeline development in Orinda/ Moraga area and allow more trails. |

## Terminal Storage Needed to Meet Water Demand During Drought

**Figure V-9**




An intertie with San Francisco's Hetch Hetchy system would have no benefit in times of shortage during a drought like 1976-77 or the drought currently being faced in 1988 when San Francisco's deficiencies are equal to or greater than EBMUD's.

The Contra Costa Water District has a sufficient quantity of Delta water available under its USBR contract to provide some water to EBMUD in the event of a dry year shortage, but its quality is inconsistent with the treatment systems at EBMUD's major filter plants and its water quality policy. In the late fall of dry years Delta water quality is at its lowest--the extraordinary high chlorides can be in excess of 250 milligrams per liter and there are very high levels of bromides and organic contaminants from agricultural runoff. If use of Delta water is considered, then EBMUD could pump directly from the Delta. (See discussion of Delta alternative below.) **There is a possibility that a limited quantity, about 15 MGD, of treated water might be available on a seasonal basis from CCWD's Bollman Treatment Plant, but would be uncertain as to long-term availability. The pipeline and pumping plant required to deliver water from the treatment plant to the Mokelumne Aqueducts would cost about $1 million.**

The State Water Project pumps water from the southern Delta to Bethany Reservoir for the California Aqueduct and for the South Bay Aqueduct extending to southern Alameda County and Santa Clara County. As with the Hetch Hetchy source, a major transmission pipeline would be needed for a connection. It would have to be located between the EBMUD system and either Bethany Reservoir or the South Bay Aqueduct at a cost that may be on the order of $400 million for treatment facilities and a pipeline. As with the CCWD source, the quality of Delta water is inconsistent with the treatment systems at EBMUD's major filter plants and its water quality policy. If use of Delta water is considered, then EBMUD could pump directly from the Delta. (See discussion of Delta alternative below.)

**A consideration would be use of State Project water from the Santa Clara Valley Water District (SCVWD), which has several sources of supply, by wheeling it through the facilities and treatment plant of the Alameda County Flood Control and Water Conservation District Zone 7 in the Livermore Valley. The limited capacity for treatment in Zone 7 would restrict this option to only 5-10 MGD. A pipeline and pumping plant would be required, but feasibility is uncertain and a specific project has not yet been developed. The cost may be on the order of $10 million.**

Interties with other agencies are not a viable nor dependable alternative for solving EBMUD's shortage problem. However, they should be considered in water supply management for limited use in emergencies.

### Delta Water Use

Water from the Delta is adequate in quantity, but its quality is inconsistent with the treatment systems at EBMUD's major filter plants and its policy on water quality. Delta water is of significantly lower quality than the Mokelumne River, and there is a concern about future public health risks associated with contaminants, particularly organic compounds. The water quality in the Delta is at its worst during dry periods when EBMUD's Mokelumne supply is reduced. EBMUD's water treatment facilities and processes are based on using a high quality source of water and would require pretreatment facilities at the source to remove turbidity, disinfect, and reduce the THM formation potential and other improvements to treat Delta water. The estimated cost would be in the range of \$200 to \$370 million, for infrequent use of Delta water. Even then, although considered to be safe, the treated water would be of lower quality and long-term health risks would be a concern.

During the 1976-77 drought, EBMUD used Delta water mixed with existing supplies. This had potentially adverse effects on the health of its customers. Significant taste and odor problems were experienced. The most serious concern was the increased level of trihalomethanes (THMs), which were caused in large part by elevated levels of bromide from sea water intrusion into the Delta. It took six years for the higher levels of THMs to be flushed out of EBMUD's terminal storage.

Since its inception, EBMUD has maintained a policy of diverting no water from the Delta for delivery to customers (with the 1977 emergency an exception). EBMUD's Citizens Advisory Committee in 1985 recommended against such diversions, and state and federal policy urges providing water from the highest quality source. The use of Delta water for delivery to EBMUD customers is not a viable alternative for solving EBMUD's shortage problem.

In response to the 1988 water shortage, EBMUD explored the concept of pumping water from the Delta back to Camanche Reservoir on the Mokelumne River, using one of the Mokelumne Aqueduct pipelines in a reverse direction. This could have provided some of the water for EBMUD's obligatory releases into the lower Mokelumne River and allow an equivalent amount of higher quality water to be diverted at Pardee Reservoir for additional delivery to the East Bay area. This concept was not approved by the State Water Resources Control Board.

### Exchange with Woodbridge Districts

Agreements between EBMUD and the Woodbridge Irrigation District and Woodbridge Water Users Conservation District provide that EBMUD will release enough water from Camanche Reservoir each year so that a Permanent Regulated Base Supply of 39,000 to 60,000 acre-feet, depending on inflow to EBMUD's reservoirs, is available for use by the Woodbridge districts; with sufficient additional releases through 1992 so that an Interim Supply of 26,855 to 56,700 acre-feet, depending on inflow and EBMUD's diversions, is also available to those districts. These agreements recognize the relative rights to Mokelumne River water held by each district.

In the Woodbridge exchange concept, EBMUD would provide a water supply to the Woodbridge districts from some other source in exchange for a commitment by those districts to reduce their Mokelumne River diversions. The other source could be from the Eastern Delta (about \$25 million for new facilities). A small amount of water could be available from possible groundwater sources in the Woodbridge area.

**The Woodbridge exchange would have a limited benefit to EBMUD because of the quantity of water involved, but it could help solve EBMUD's problem of shortage in drought periods. Another approach being developed by EBMUD is the direct purchase of water from the Woodbridge districts and other water users on the lower Mokelumne River or development of a conjunctive use project, which could increase the amount of water available to EBMUD in dry years. Discussions between EBMUD and the Woodbridge districts are continuing. The resulting decrease in river flows below Camanche Reservoir is a significant concern to the fish and wildlife agencies and would have an adverse impact on the groundwater basin unless recharge in normal and wet years can be enhanced.**

### Conclusions Regarding Shortage Alternatives

From the above analysis of shortage alternatives, the most feasible and cost-effective approach to solving the problem of water shortage during a drought is water banking with the construction of additional terminal storage. Also, it offers the possibility of a multi-purpose solution in conjunction with the problem of security. Capacity should be based on surviving a repeat of a drought like 1976-77 and a projected demand of 270 MGD in 2020, which is the mid-

range growth rate and assumes full implementation of current water conservation and reclamation programs. A 25 percent demand reduction during the second year of the shortage should be part of the planning to reduce the severity of rationing and accommodate increased efficiency of water use. The amount of the additional storage would be 95,000 acre-feet at an estimated cost of $115 to $146 million. The integration of this capacity with the storage required for security is discussed later in this chapter.

Water conservation cannot solve the shortage problem unless normal year demand is significantly reduced by unusual mandatory measures, with major investment by customers in water saving equipment and impacts on the economy and lifestyle of the East Bay area.

The American River supply under the USBR contract is not an alternative, as discussed later in this chapter. This does not affect the selection of water banking as the most-feasible alternative.

The Delta could provide an adequate quantity of water, but the quality under normal conditions is inconsistent with EBMUD treatment systems and its policy on water quality. During drought the flows into the Delta are lower, further lowering the quality particularly in the fall. The concept of pumping water from the Delta back to Camanche Reservoir is being explored in response to the 1988 water shortage. This could provide some of the water needed for EBMUD's obligatory releases into the lower Mokelumne River and would offset some of the rationing required.

Other options would not be solutions to the shortage problem, but would provide benefits and should be pursued as part of a balanced water supply management program: Additional water conservation measures and wastewater reclamation projects to increase the efficiency of water use; exchange of water with the Woodbridge districts; and conduct studies of intertie improvements with other agencies.

## ANALYSIS OF SAFETY AND HEALTH ALTERNATIVES

### Need for Improvements

Although EBMUD treated water is superior to state and federal standards, EBMUD continues to modernize its treatment plants, improve its taste and odor control capabilities, pursue advance treatment technologies in anticipation of future drinking water regulations, and evaluate future alternative treatment technologies. EBMUD is currently undertaking approximately $35 million in improvements as part of its ongoing treatment improvement program.

EBMUD owns approximately 26,000 acres of watershed land in the East Bay area. The East Bay Regional Park District and other public agencies own about 20,000 acres of open space contiguous with EBMUD's watershed lands. Watershed management is essential to providing high quality water to prevent sewage and other pollutants from entering the terminal reservoirs. Ongoing watershed reconnaissance, water quality monitoring, and land management activities will continue.

### Watershed Enhancement

Watershed management would be improved by EBMUD's purchase of watershed lands currently in other ownership and which may have a potential for development. Acquisition of the land to the ridgelines around the terminal reservoirs to the extent possible would help assure that the high quality of stored water can be maintained in the future. Acquisitions could also minimize ridgeline development in the Moraga/Orinda area (San Pablo and Upper San Leandro watersheds) and provide opportunities for significant trail enhancement. A program for acquiring about 3,500 acres of watershed has an estimated cost of $20 million.

### Water Quality Considerations of Security and Shortage Alternatives

**The final quality of the water delivered to the consumer depends on two factors: the quality of the source water and the effectiveness of treatment. Figure V-10 compares water quality control strategies relative to several water quality issues.**

**The sources available to the District are its Mokelumne River supply and the Delta in the near term plus the American River in the future. The American River is the source most similar to the Mokelumne River and Delta sources have the lowest water quality. If Delta water were planned to be used as a supplemental or an emergency source, significant water treatment improvements in addition to those already planned would be required, the additional costs of which are included in the security and shortage alternatives.**

**Beyond the treatment cost differences among the sources, a greater, non-monetary difference exists: risk to public health. The Mokelumne and American river watersheds are protected from a multitude of natural hazards such as organic compounds (e.g., pesticides, urban storm runoff, chemical spills). The greater the hazard to the watershed, the greater the risk to public health, even with the best treatment available.**

## Comparison of Water Quality Control Strategies

Figure V-10

| WATER QUALITY ISSUES | WATER QUALITY CONTROL STRATEGY | | | CONCLUSIONS |
|---|---|---|---|---|
| | NO PROJECT | USE HIGH QUALITY/PROTECTED SOURCES | IMPROVE TREATMENT | |
| THMs | Probably will be unable to meet Disinfection Byproducts Rule. | Sources with low THMFP will be treatable with lower cost and/or to lower THM levels. | Probably will need some capital improvements; cost varies greatly with source water. | Use sources low in THMFP, improve treatment as required. |
| Taste & Odor | T&O will continue to be a seasonal problem with terminal reservoirs and when Delta is used as an emergency source. | T&O will continue to pose few or no problems for Sierra sources. | T&O in terminal reservoirs can be greatly reduced with GAC and ozone, but probably not eliminated. | Improve treatment; however, no amount of treatment can totally eliminate effect of source. |
| Excessive Salinity | Severe problem during extended outages of the Mokelumne Aqueduct when Delta is used as an emergency source. | Salinity is not a problem for any source except the Delta. | Tremendous cost associated with salinity removal. | Avoid Delta as a source. |
| Pesticides | Only a threat for relatively unprotected sources, e.g. Delta. | Protected sources with limited pesticide use in their watershed are the only sure method of avoiding health threats. | Can be treated, but "safe" levels not been defined and measurement is difficult. | Use protected sources, i.e., those not exposed to agriculture. |
| Chemical Contamination | Unprotected sources will continue to be subject to tanker truck spills, urban runoff, etc. | Protected sources offer the only protection from spills and urban development. | Impossible to treat gross contamination which could result from spill. | Use protected sources, i.e., those not exposed to development, urban runoff or heavy traffic. |
| Future Regulations | Likely that standards will be violated. | Many regulations will already be met for protected sources; any needed improvements will be relatively minor. | Treatment improvements will continuously be under construction, at great cost. No guarantee that all future regulations can be met with treatment alone. | Use protected source in order to allow maximum flexibility and improve treatment as required. |
| Unknown Organics | Human health effects unknown; assumed to be adverse. | The safest, surest method. | May or may not remove "enough" of the organics. | Use protected source to afford protection against unidentified contaminants. |

**The public has indicated repeatedly in recent years that they are not willing to accept any risk from its drinking water and that they are willing to pay to improve water quality. This attitude is exemplified by the passage of measures such as Proposition 65 and the high usage of bottled water state-wide.**

**In Chapter IV it is concluded that EBMUD's present policy of seeking sources of the highest quality for both normal use and use during emergenices should continue, and EBMUD should use Sierra sources only and avoid the use of Delta water.**

## COMPOSITE PROGRAM OPTIONS

**The security and shortage alternatives can be combined into a variety of composite program options to reduce future demand and provide additional supplies during outage and drought as solutions to EBMUD's water supply problems. The program options in Figures V-11 through V-14 illustrate the combinations of alternatives that can be compared and considered in arriving at the proposed program. There are other combinations that could also be considered.**

# Composite Program Option 1

**Figure V-11**

## OPTION 1

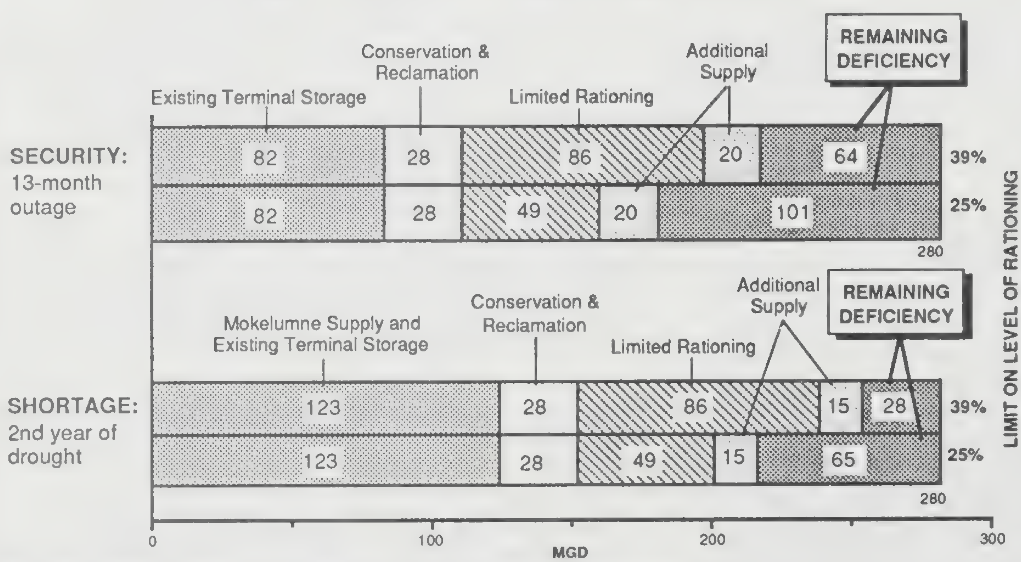
Emphasis on conservation and reclamation in normal years, with lowest cost alternatives for additional supplies in outage or drought shortage.

● PROPOSED ALTERNATIVE

○ PILOT PROGRAM OR STUDY

| | | REDUCE FUTURE DEMAND | | | | | | | PROVIDE SUPPLY DURING OUTAGE OR SHORTAGE | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | WATER CONSERVATION | | | | | WATER RECLAMATION | | | NEW PIPELINE ACROSS THE DELTA | | WATER BANKING | | | INTERTIES WITH OTHER AGENCIES | | | | USE OF DELTA WATER | | OTHER SOURCE | | |
| | 1. Do Nothing | 2.1 Existing Program | 2.2 Landscape and Water Management | 2.3 Ultra Low Flow Toilets and Showers | 2.4 Water Saving Technology | 2.5 Landscape Rebate Program | 3.1 Chevron and Alameda Projects | 3.2 San Ramon Valley Irrigation | 4. Levee Improvements in the Delta | 5.1 Limited Capacity Pipeline | 5.2 Full Capacity Pipelines | 6.1 Pinole Reservoir | 6.2 Buckhorn Reservoir | 6.3 Los Vaqueros Reservoir | 7.1 Hayward Treated Water | 7.2 Contra Costa WD Treated Water | 7.3 Hetch Hetchy Untreated Water | 7.4 Alameda Co. Zone 7 Treated Water | 8.1 No Pretreatment | 8.2 With Pretreatment | 9.1 Exchange with Woodbridge | 9.2 Mokelumne Conjunctive Use | 10. Watershed Enhancement |
| ALTERNATIVES INCLUDED IN OPTION | — | ● | ● | ● | ● | ● | ● | ○ | ● | — | — | — | — | — | ● | ● | — | — | — | — | ● | ○ | ● |
| SECURITY — WATER SAVINGS/SUPPLY (MGD) | | 23 | | | | | 5 | | — | | | | | | 20 | | | | | | 0 | | — |
| SHORTAGE — WATER SAVINGS/SUPPLY (MGD) | | 23 | | | | | 5 | | — | | | | | | 5 | | | | | | 10 | | |
| MEETS WATER QUALITY OBJECTIVES? | | YES | | | | | YES | | Y | | | | | | NO | | | | | | YES | | Y |
| COST ($ MILLION) | | 12 PER YEAR | | | | | 17 | | 8 | | | | | | 1 | | | | | | 25 | | 20 |

### RESULTING SUPPLY CONDITIONS IN 2020




### ESTIMATED TOTAL COST

| | $ MILLION |
|---|---|
| TOTAL CAPITAL COST: | 71 |
| PRESENT WORTH OF ANNUAL COSTS: | 137 |
| TOTAL: | 208 |

REMARKS:

- Conservation alternatives 2.3, 2.4, and 2.5 need pilot study of effectiveness.
- Reclamation alternative 3.2 may not be economically feasible.
- Exchange with Woodbridge has questionable feasibility and there would be concerns about reduced flows in the lower Mokelumne River.
- This option does not meet security and shortage objectives.

# Composite Program Option 2

Figure V-12

## OPTION 2

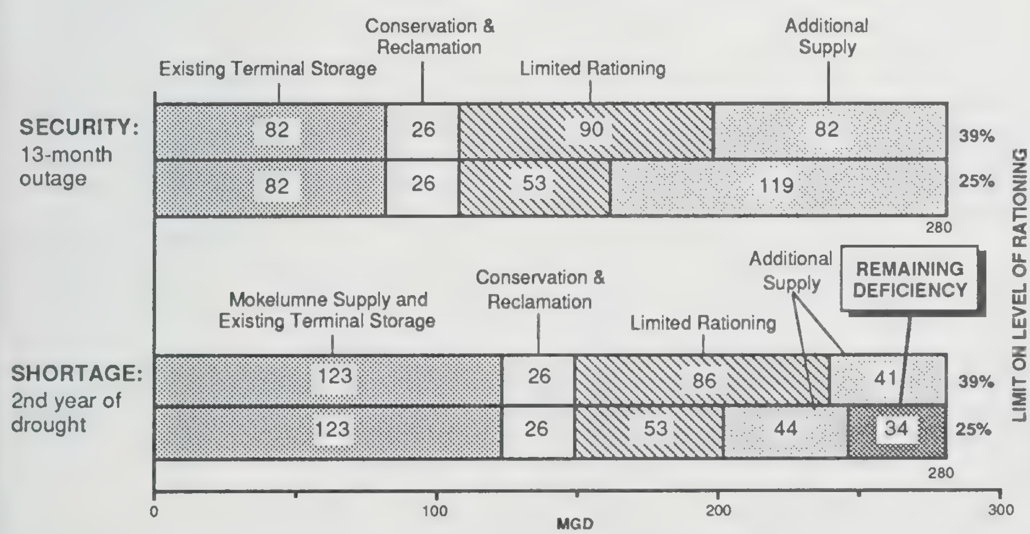
Emphasis on new aqueduct pipeline across the Delta for security and water banking with a smaller reservoir for shortages, with conservation to include ultra low flow fixtures.

● PROPOSED ALTERNATIVE

○ PILOT PROGRAM OR STUDY

| | | REDUCE FUTURE DEMAND | | | | | | | PROVIDE SUPPLY DURING OUTAGE OR SHORTAGE | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | WATER CONSERVATION | | | | | WATER RECLAMATION | | | NEW PIPELINE ACROSS THE DELTA | | WATER BANKING | | | INTERTIES WITH OTHER AGENCIES | | | | USE OF DELTA WATER | | OTHER SOURCE | | |
| | 1. Do Nothing | 2.1 Existing Program | 2.2 Landscape and Water Management | 2.3 Ultra Low Flow Toilets and Showers | 2.4 Water Saving Technology | 2.5 Landscape Rebate Program | 3.1 Chevron and Alameda Projects | 3.2 San Ramon Valley Irrigation | 4. Levee Improvements in the Delta | 5.1 Limited Capacity Pipeline | 5.2 Full Capacity Pipelines | 6.1 Pinole Reservoir | 6.2 Buckhorn Reservoir | 6.3 Los Vaqueros Reservoir | 7.1 Hayward Treated Water | 7.2 Contra Costa WD Treated Water | 7.3 Hetch Hetchy Untreated Water | 7.4 Alameda Co. Zone 7 Treated Water | 8.1 No Pretreatment | 8.2 With Pretreatment | 9.1 Exchange with Woodbridge | 9.2 Mokelumne Conjunctive Use | 10. Watershed Enhancement |
| ALTERNATIVES INCLUDED IN OPTION | — | ● | ● | ● | ○ | ○ | ● | — | ● | ● | — | ● | — | — | ● | ● | ○ | ○ | — | — | — | ○ | ● |
| SECURITY — WATER SAVINGS/SUPPLY (MGD) | | 21 | | | | | 5 | | — | 170 | | 36 | | | 20 | | | | | | 0 | | — |
| SHORTAGE — WATER SAVINGS/SUPPLY (MGD) | | 21 | | | | | 5 | | — | 0 | | 39 | | | 5 | | | | | | 10 | | — |
| MEETS WATER QUALITY OBJECTIVES? | | YES | | | | | YES | | Y | YES | | YES | | | NO | | | | | | YES | | Y |
| COST ($ MILLION) | | 12 PER YEAR | | | | | 16 | | 8 | 170 | | 60 | | | 1 | | | | | | 25 | | 20 |

### RESULTING SUPPLY CONDITIONS IN 2020




### ESTIMATED TOTAL COST

| | $ MILLION |
|---|---|
| TOTAL CAPITAL COST: | 275 |
| PRESENT WORTH OF ANNUAL COSTS: | 137 |
| TOTAL: | 412 |

REMARKS:

- New aqueduct pipeline requires field testing of pipeline support designs and studies of levee reinforcements.
- A program of replacing toilets with low flow models has an annual cost of $10—13 million per year.
- Treated water from CCWD may not meet EBMUD water quality policy.

# Composite Program Option 3

Figure V-13

## OPTION 3

Emphasis on use of fully treated Delta water during outage or shortage, with feasible conservation measures and reclamation.

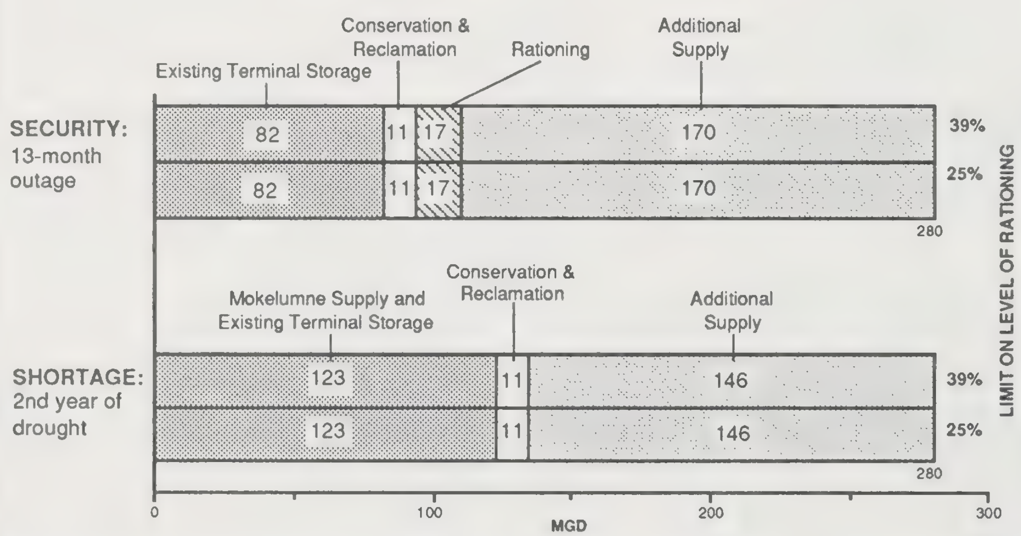
● PROPOSED ALTERNATIVE

○ PILOT PROGRAM OR STUDY

| | | Alternatives included in option |
|---|---|---|
| | 1. Do Nothing | — |
| REDUCE FUTURE DEMAND — WATER CONSERVATION | 2.1 Existing Program | ● |
| | 2.2 Landscape and Water Management | ● |
| | 2.3 Ultra Low Flow Toilets and Showers | ○ |
| | 2.4 Water Saving Technology | ○ |
| | 2.5 Landscape Rebate Program | ○ |
| REDUCE FUTURE DEMAND — WATER RECLAMATION | 3.1 Chevron and Alameda Projects | ● |
| | 3.2 San Ramon Valley Irrigation | — |
| PROVIDE SUPPLY DURING OUTAGE OR SHORTAGE | 4. Levee Improvements in the Delta | ● |
| NEW PIPELINE ACROSS THE DELTA | 5.1 Limited Capacity Pipeline | — |
| | 5.2 Full Capacity Pipelines | — |
| WATER BANKING | 6.1 Pinole Reservoir | — |
| | 6.2 Buckhorn Reservoir | — |
| | 6.3 Los Vaqueros Reservoir | — |
| INTERTIES WITH OTHER AGENCIES | 7.1 Hayward Treated Water | ○ |
| | 7.2 Contra Costa WD Treated Water | ○ |
| | 7.3 Hetch Hetchy Untreated Water | ○ |
| | 7.4 Alameda Co. Zone 7 Treated Water | ○ |
| USE OF DELTA WATER | 8.1 No Pretreatment | — |
| | 8.2 With Pretreatment | ● |
| OTHER SOURCE | 9.1 Exchange with Woodbridge | — |
| | 9.2 Mokelumne Conjunctive Use | ○ |
| | 10. Watershed Enhancement | ● |

| | 1. Do Nothing | Water Conservation | Water Reclamation | 4. Levee Improvements | New Pipeline Across the Delta | Water Banking | Interties with Other Agencies | Use of Delta Water | Other Source | 10. Watershed Enhancement |
|---|---|---|---|---|---|---|---|---|---|---|
| SECURITY — WATER SAVINGS/SUPPLY (MGD) | | 6 | 5 | — | | | — | 170 | | — |
| SHORTAGE — WATER SAVINGS/SUPPLY (MGD) | | 6 | 5 | — | | | — | 145 | | — |
| MEETS WATER QUALITY OBJECTIVES? | | YES | YES | Y | | | — | NO | | Y |
| COST ($ MILLION) | | 0.8 PER YEAR | 17 | 8 | | | — | 495 | — | 20 |

### RESULTING SUPPLY CONDITIONS IN 2020




### ESTIMATED TOTAL COST

| | $ MILLION |
|---|---|
| TOTAL CAPITAL COST: | 540 |
| PRESENT WORTH OF ANNUAL COSTS: | 9 |
| TOTAL: | 549 |

REMARKS:
- The planned use of Delta water requires construction of treatment facilities: pretreatment and reduction of THM potential ($370 million) plus desalinization ($125 million minimum).)
- Pretreatment of Delta water does not eliminate the concern about the long term health risks associated with that source.

## Composite Program Option 4

Figure V-14

### OPTION 4

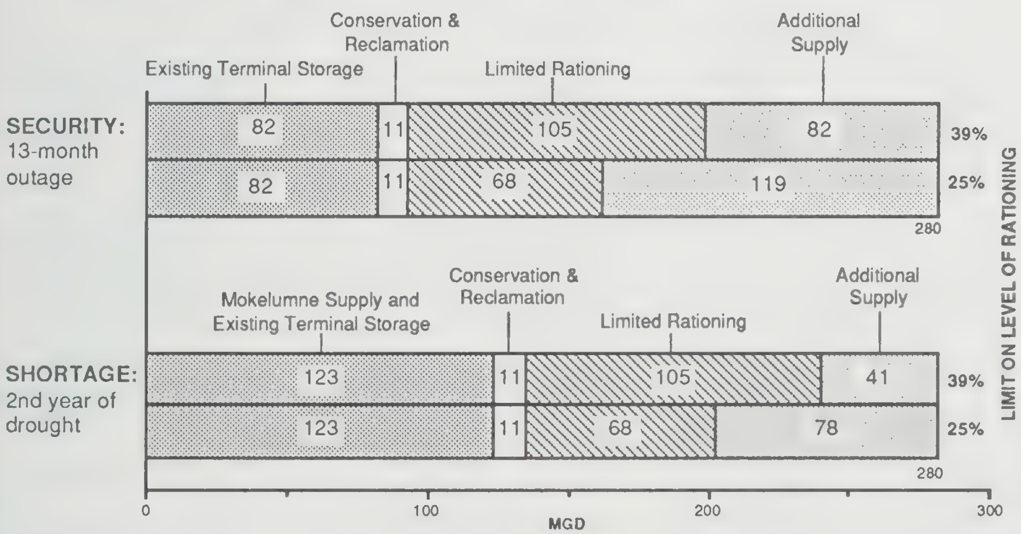
Emphasis on additional terminal storage with feasible conservation and reclamation.

● PROPOSED ALTERNATIVE

○ PILOT PROGRAM OR STUDY

| | | REDUCE FUTURE DEMAND | | | | | | | PROVIDE SUPPLY DURING OUTAGE OR SHORTAGE | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | WATER CONSERVATION | | | | | WATER RECLAMATION | | | NEW PIPELINE ACROSS THE DELTA | | WATER BANKING | | | INTERTIES WITH OTHER AGENCIES | | | | USE OF DELTA WATER | | OTHER SOURCE | | |
| | 1. Do Nothing | 2.1 Existing Program | 2.2 Landscape and Water Management | 2.3 Ultra Low Flow Toilets and Showers | 2.4 Water Saving Technology | 2.5 Landscape Rebate Program | 3.1 Chevron and Alameda Projects | 3.2 San Ramon Valley Irrigation | 4. Levee Improvements in the Delta | 5.1 Limited Capacity Pipeline | 5.2 Full Capacity Pipelines | 6.1 Pinole Reservoir | 6.2 Buckhorn Reservoir | 6.3 Los Vaqueros Reservoir | 7.1 Hayward Treated Water | 7.2 Contra Costa WD Treated Water | 7.3 Hetch Hetchy Untreated Water | 7.4 Alameda Co. Zone 7 Treated Water | 8.1 No Pretreatment | 8.2 With Pretreatment | 9.1 Exchange with Woodbridge | 9.2 Mokelumne Conjunctive Use | 10. Watershed Enhancement |
| ALTERNATIVES INCLUDED IN OPTION | — | ● | ● | ○ | ○ | ○ | ● | — | ● | — | — | — | — | — | ○ | ○ | ○ | ○ | — | — | — | ○ | ● |
| SECURITY — WATER SAVINGS/SUPPLY (MGD) | | 6 | | | | | 5 | | — | | | 82—119 | | | | | | | | | | | — |
| SHORTAGE — WATER SAVINGS/SUPPLY (MGD) | | 6 | | | | | 5 | | — | | | 41—78 | | | | | | | | | | | — |
| MEETS WATER QUALITY OBJECTIVES? | | YES | | | | | YES | | Y | | | YES | | | | | | | | | | | Y |
| COST ($ MILLION) | | 0.8 PER YEAR | | | | | 17 | | 8 | | | 152* | | | | | | | | | | | 20 |

### RESULTING SUPPLY CONDITIONS IN 2020




### ESTIMATED TOTAL COST

| | $ MILLION |
|---|---|
| TOTAL CAPITAL COST: | 197 |
| PRESENT WORTH OF ANNUAL COSTS: | 9 |
| TOTAL: | 206 |

REMARKS:

- Joint project with CCWD on Los Vaqueros could provide same storage as Buckhorn, if Sierra water is used, at an estimated cost of $186 million (vs. $152).
- For security, storage would be:
  100,000 acre-feet for 39% limit on rationing — would provide 82 MGD
  145,000 acre-feet for 25% limit on rationing — would provide 119 MGD

*The operational cost of the initial filling of the reservoir would be about $17 million.

Any proposed program should also include other elements that are important to EBMUD's management of its water supply, but do not provide for a reduction in future demand or additional supplies. These are the levee improvements in the Delta (Alt. 4.1), preliminary engineering for foundation improvements in the Delta, and continuation of the Treatment Improvement Program.

Option 1 (Figure V-11) places emphasis on water conservation and reclamation alternatives, low cost interties, and exchange of water. The untested, more-theoretical conservation measures in Alternatives 2.3, 2.4, and 2.5 could have the potential savings indicated, but should first be subject to pilot testing to develop the requirements and expected benefits. The water reclamation alternative of an irrigation project in the San Ramon Valley has been studied, and was found not to be economically feasible unless more users can be identified. EBMUD has attempted, without success, to develop an exchange project with Woodbridge Irrigation District and Woodbridge Water Users Association. EBMUD has also tried to purchase Woodbridge water and received an initial negative response, but those discussions are continuing. Considering the existing policy of a 39 percent limit on rationing and the proposed 25 percent limit, Option 1 would not solve the security and shortage problems because of the significant remaining deficiencies.

Option 2 (Figure V-12) places emphasis on a new aqueduct pipeline across the Delta for security and on water banking with a reservoir to provide a supply during drought shortages. The new pipeline would meet the security objective, but would not provide any additional supply for shortages. Water banking with the smaller reservoir would be adequate during a repeat of 1976-77 conditions under the current 39 percent limit on rationing, but there would be a remaining deficiency if a 25 percent limit should be adopted.

Option 3 (Figure V-13) places emphasis on the use of Delta water as a supply for both security and shortage. The use of Delta water without full treatment has been permitted in unexpected emergencies. However, the planned future use of Delta water without adequate treatment is not acceptable and would not be permitted by the State Health Department. Therefore, additional treatment facilities would be required for this option. The pretreatment alternative (Alt. 8.2) would include pretreatment facilities at the Delta source to remove turbidity and ozonation for disinfection. It also would include granulated activated carbon (GAC) facilities to reduce the trihalomethane formation potential to the same low level that the use of Mokelumne water could produce. Even with these pretreatment facilities, the ability to use Delta water to help meet demand during a drought shortage would depend on the quality of Delta water at the time of diversion, which may be negatively impacted by the reduction in freshwater flows. In the event of an outage caused by an earthquake disaster in the Delta, the salinity is expected to be too high to permit any use of Delta water if only conventional pretreatment is provided. Therefore, desalinization is also part of this option. A problem with desalinization is the need to dispose of the brine generated by the reverse osmosis treatment process. This treatment does not eliminate the concern about the long-term health risks associated with use of Delta water.

Option IV (Figure V-14) places emphasis on water banking--additional terminal storage as a solution to both the security and shortage problems. The size of the reservoir would depend on the limit on the level of rationing, either the current policy of 39 percent or an improvement to 25 percent or another level. The cost shown in this option is for Buckhorn Reservoir with 145,000 acre-feet of storage based on a proposed change in EBMUD policy to a 25 percent level of rationing. The same storage could be provided in Contra Costa Water District's proposed Los Vaqueros Reservoir at an estimated cost of $186 million.

## CONCLUSIONS ON THE MOST-FEASIBLE ALTERNATIVES

### Water Banking--Additional Terminal Storage

From the conclusions related to both security and shortage needs, water banking appears as the most-feasible and cost-effective solution. Thus, it would be a multi-purpose solution to EBMUD's water supply needs. It would also meet the water quality objective related to safety and health because the stored water would be from the Mokelumne River.

The storage required at a future demand of 280 MGD in 2020, reduced by water conservation and water reclamation to 270 MGD, is shown in Figure V-15. The capacity required for surviving a drought like 1976-77 and surviving a 13-month outage of the Mokelumne supply are shown as separate considerations. Also shown is the capacity needed for a condition where a major earthquake affecting the Delta and a worst-case drought occur in immediate sequence. However, the risk of sequential events is very small and the proposed storage would therefore

## Additional Storage Required

Figure V-15

| RATIONING: Demand Reduction | SECURITY: 13-month Supply Outage | SHORTAGE: Repeat of 1976-77 Drought | Sequential Events |
|---|---|---|---|
| 39% | 100,000 AF | 55,000 AF | 150,000 AF |
| 25% | 145,000 AF | 95,000 AF | 235,000 AF |

AF= acre-feet

be based on security, which has the greater requirement. If the planned demand reduction (rationing) during an outage is kept at the current policy level of 39 percent, the additional terminal storage would be 100,000 acre-feet. But the planned demand reduction should be reduced to 25 percent to reduce the severity and to accommodate increased water use efficiency. In that case the proposed storage is 145,000 acre-feet.

### Watershed Enhancement

To meet the safety and health objective of maintaining high quality water, acquire additional watershed land to the ridgelines around the terminal reservoirs to the extent possible, at an estimated cost of $20 million.

### Other Considerations

From the discussions of alternatives for security, shortage, and safety and health, several other options emerge which do not solve the water supply problems, but provide benefits and are important to a complete and balanced water supply management program:

- Water conservation---continue implementation of the current program and adopt additional measures, which would save 6 MGD by 2020; continue analyses and studies for future expansion of the program.

- Water reclamation---continue to develop reclamation projects, which would save about 5 MGD by 2020; seek additional opportunities for feasible projects.

- Levee improvements in the Delta---continue levee maintenance, repair, and upgrading to offset the deteriorating conditions in the Delta.

- Foundation studies in the Delta:

  - Investigation and feasibility studies of levee reinforcement and of modification of supports under the existing aqueduct pipelines to reduce the risks of aqueduct damage due to flooding and lower levels of ground shaking caused by earthquakes.

  - Field testing and preliminary design of possible pile support systems and a future aqueduct pipeline across the Delta to shorten the response time in the event of a disaster.

- Intertie improvements with other agencies---undertake studies to increase the capacity of the existing connections with the Hetch Hetchy system through the City of Hayward and to further explore the feasibility of a direct intertie with the Hetch Hetchy system and the possibility of an intertie with CCWD.

- Woodbridge exchange---continue to explore the possibility of exchanging water with the Woodbridge districts or a conjunctive use project to increase the water available from the Mokelumne River during shortages.

- Treatment improvement program---continue the treatment plant improvements at a cost of $35 million. At the same time continue to pursue advance treatment technologies.

### Compatibility with Future Decisions and Needs

A decision to construct additional terminal storage for solving the problems of security and shortage and other elements of water supply management should be compatible with any future decisions regarding EBMUD's water supply needs. Selection of a proposed program today will be based on a reasonable assessment of conditions in the next decade and extending out more than 30 years to 2020. Conditions can be expected to change within that period, and EBMUD's water supply needs will extend on into the future beyond 2020.

If demand continues to increase beyond the year 2020 to levels higher than 270 MGD, terminal storage will again become insufficient to provide security against an extended outage of water supply delivery system and additional facilities would have to be constructed. The construction of additional terminal storage now and levee and foundation improvements in the Delta would be consistent with the long-term security needs.

### Bureau of Reclamation Contract

**Implementation of EBMUD's contract with the USBR for a supplemental supply from the American River via the Folsom South Canal (see Chapter I) will be decided after the current litigation is resolved. There is a possibility of extensive delays in the current Superior Court trial**

and as the matter subsequently moves through the appellate courts. But even if it was available immediately, the supplemental supply would not address the Water Supply Management Program objectives for security and shortage. It would have a number of other benefits, which are discussed below.

The Report of Referee issued by the State Water Resources Control Board and now under consideration by the Alameda County Superior Court recommends that EBMUD would have to cease taking delivery of American River water from the USBR when flows in the lower American River drop below specified minimum levels. Thus, in dry years, EBMUD would be subject to severe limitations in the amount of water which it could receive from the American River, and in a year like 1977 could not take delivery of any water. Therefore, EBMUD would not be able to rely upon the American River supplemental supply alone as a meaningful and dependable source of water to help overcome deficiencies in dry years or as a dependable source to guard against extended outages of the Mokelumne supply.

Protection against an outage is needed regardless of the source of water--Mokelumne or American River--and regardless of the increased supply that could become available. Construction of a pipeline between the turnout on the Folsom South Canal and the Mokelumne Aqueducts to the south would be the most direct and least expensive connection for delivery of the American River supply, which means that it would be interrupted the same as the Mokelumne supply in the event of a disaster in the Delta. The alternative of a longer pipeline connection extending westerly from the Canal turnout to the west side of the Delta and then south to the Mokelumne Aqueducts at West Pittsburg might overcome this vulnerability at a significantly greater cost; however, the availability of American River water during an extended outage would then be affected by the recommendations of the State Water Resources Control Board in the current litigation.

Additional terminal storage would help to utilize the supplemental supply from the American River for other than security purposes. Water could then be carried over from the time when it is available to the dry years when it will be needed. With a projected demand of 270 MGD in the year 2020 in a repeat of historic drought conditions, the use of American River water under the USBR contract in accordance with the State Board's proposed recommendations would require the additional storage shown in Figure V-16. Also shown, for comparison, are the terminal storage requirements developed for security and shortage without the supplemental supply.

Figure V-16 shows that the supplemental American River supply does not eliminate the need for nor change the size of additional terminal storage proposed for the Water Supply Management Program, which is governed by the capacity needed for security to protect against an extended water supply outage. Thus, that storage for security is needed with or without the supplemental American River supply. That means a decision now to construct an additional terminal reservoir would not be based on whether the USBR contract will be implemented in the future. For these reasons, the USBR contract is not an alternative in the proposed Water Supply Management Program and the current water supply problems must be resolved independent of the future American River supply.

When implemented, the supplemental American River supply could provide a number of benefits for EBMUD and its customers. It could increase the District's total supply going into the second year of a drought like 1976-77, by about 30 MGD. (If additional terminal storage is not constructed, there would be a 48 percent level of rationing required.) The supplemental supply would have the

## Additional Storage for Supplemental Supply

Figure V-16

| LIMIT ON RATIONING | ADDITIONAL STORAGE REQUIRED FOR DROUGHT SHORTAGE | | ADDITIONAL STORAGE REQUIRED FOR SECURITY, WITH OR WITHOUT AMERICAN RIVER |
|---|---|---|---|
| | WITH AMERICAN RIVER SUPPLY | WITHOUT AMERICAN RIVER SUPPLY | |
| 39% | 25,000 acre-feet | 55,000 acre-feet | 100,000 acre-feet |
| 25% | 68,000 acre-feet | 95,000 acre-feet | 145,000 acre feet |
| 0% | 144,000 acre-feet | 203,000 acre-feet | 237,000 acre-feet |

advantage of reducing the rationing hardship during a drought with or without additional storage. Following a period of shortage or extended outage when EBMUD would be using up its storage, the supplemental supply would improve the subsequent storage recovery time particularly if Mokelumne River runoff is on the low side. The supplemental supply could also be used to offset any supply loss should fishery studies on the lower Mokelumne River or the Bay-Delta proceedings result in a requirement that EBMUD release more water below Camanche Reservoir.

It should be noted that the calculations with regard to availability of Mokelumne and American River water and water supply needs are based on analyses in relation to historic hydrology, and in particular the significant drought periods of 1928-34 and 1976-77. A longer drought period with runoff as low as 1976-77 continuing into a third year or longer would create a more serious water supply emergency that the supplemental supply could help mitigate by storing water when it is available.

For the long term, and recognizing that EBMUD's water supply planning and management will extend beyond the current planning period ending in 2020, the supplemental American River supply would assure that EBMUD has adequate water resources to meet its obligations and to offset continued increases in water use in the Mokelumne River basin by senior rights holders. The supplemental supply will be part of the District's long-range water supply planning, separate and distinct from the current issues being addressed in the proposed Water Supply Management Program. Separate environmental documentation will be prepared for the facilities needed to deliver the supplemental supply to EBMUD.

## ALLOCATION OF COSTS AND FINANCING

The allocation of costs for the proposed elements of the Water Supply Management Program is based on how the facilities would be used and whom they would benefit. The following is a brief description of the analysis made to determine the allocation of costs and financing for the projects.

### Water Conservation Program

The water conservation program is of benefit to all customers. The program will be financed by an increase in the water rates to all customers. This represents the cost of additional water conservation measures beyond the Base Case measures, which are already in place. Annual cost for the additional measures is estimated to be $496,000/yr in 1988 dollars, for a total water conservation program cost of about $755,000 per year. The average increase in a typical monthly water bill would be about $0.05 for the additional measures. There will be no increase in the System Capacity Charges (SCC) resulting from the water conservation program.

### Water Reclamation Projects

In order to keep the price of reclaimed water competitive with potable water, the Water Conservation and Development Fund will be used to finance much of the capital construction. In accordance with the recently adopted policy on the Sale of Reclaimed Water, the price of reclaimed water will generate sufficient revenues which, when combined with connection charge revenues, will recover all District costs to the extent possible without increasing the overall cost to the user. The estimated capital cost for water reclamation projects is up to $16.6 million in 1988 dollars. However, there will be no increase in the water rates or SCC resulting from the implementation of water reclamation projects.

### Improvements in the Delta

Levee and foundation improvements, including preliminary engineering, will help ensure the security of the District's water supply system, and this is a benefit to all customers. The cost of this program will be financed by an increase in the water rates to all customers. The estimated capital cost for the program is about $10 million in 1988 dollars. The money will be raised through the issuance of bonds. The average increase in a typical monthly water bill would be about $0.11.

### Treatment Improvement Program

The treatment improvement program is a comprehensive program planned to assure that water quality will meet future drinking water regulations, to improve the aesthetic qualities of the water, and to improve treatment operations in terms of flexibility, reliability and cost. The program is a benefit to all customers and is being financed by an increase in the water rates to all customers. The estimated cost for the program is about $35 million in 1988 dollars. The money will be raised through the issue of bonds. The average increase in a typical monthly water bill is about $0.30.

### Protect Existing Sources

The estimated cost to purchase additional watershed to the ridgelands around the existing and any

proposed terminal reservoirs would be about $20 million in 1988 dollars. The money will be raised through the issuance of bonds. The average increase in a typical monthly water bill would be about $0.11.

### Additional Terminal Storage

A new 145,000 acre-feet reservoir would be used to provide security during extended outages of the water supply and also to accommodate demand increases by providing additional water for regulation, 120 days standby and use during droughts. Security is a benefit to all customers while accommodating future demands is a benefit to new customers. A composite picture of the cost allocation is shown in Figure V-17. Forty-three (43) percent of the cost will be paid for by existing customers through an increase in the water rates. The other 57 percent will be paid for by new customers through an increase in the SCC, although a small portion will come from the water rates paid by those new customers. The estimated cost for Buckhorn Reservoir is about $152 million in 1988 dollars. About $152 million will be financed through the issuance of bonds.

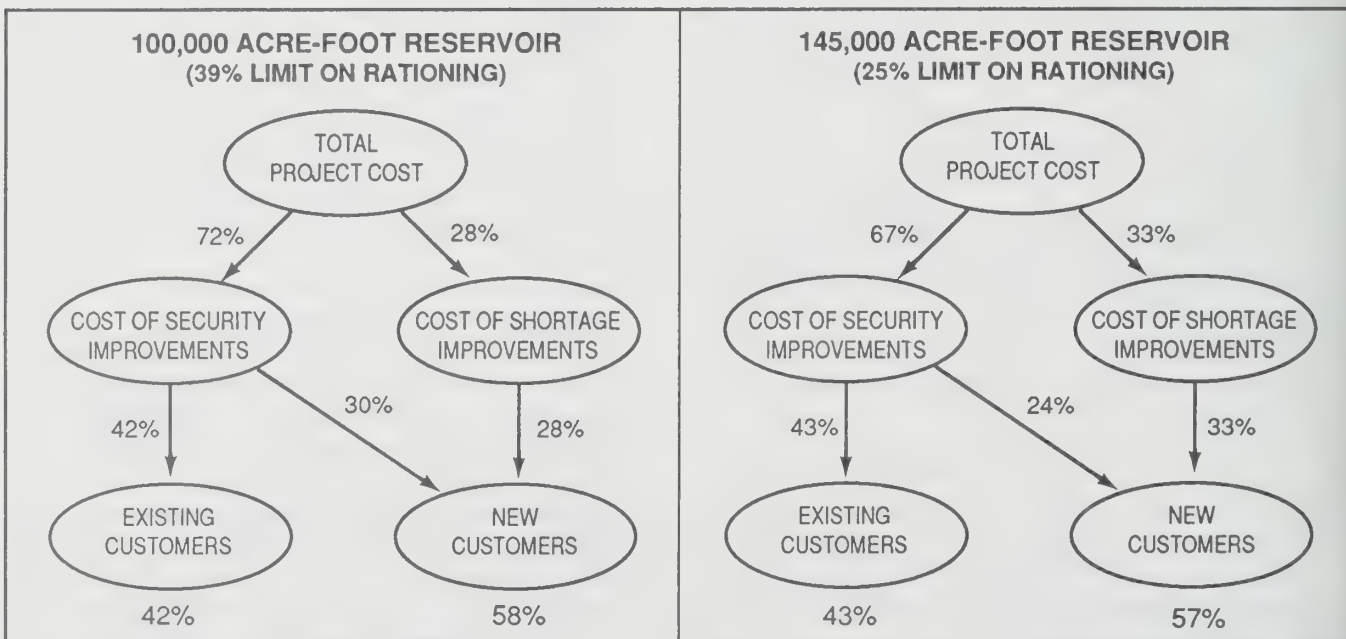
Figure V-18 shows the increase in rates and SCC needed to finance the reservoir project. The average increase in a typical monthly water bill for existing customers to pay back 43 percent of the bonds for a 145,000 acre-feet Buckhorn Reservoir is about $0.81. The average increase in SCC needed for new customers to pay back the remaining 57 percent of capital cost is about $350 per 100 gpd. The SCC will begin in 1989.

## PROPOSED WATER SUPPLY MANAGEMENT PROGRAM

The proposed projects for the Water Supply Management Program are summarized in Figure V-19. The public review process for the revised Draft Water Supply Management Program and revised Draft Environmental Impact Report is anticipated in the latter part of 1988. In addition to the public comment period, a public hearing and a public meeting will be held to receive comments on the key issues, needs, and revised Draft EIR. A schedule of the process is included as Figure V-20. Implementation of the proposed projects is anticipated to begin in the latter part of 1988 upon EBMUD's Board of Directors' approval of the Water Supply Management Program. A preliminary implementation schedule is provided as Figure V-21.

## Summary of Terminal Storage Cost Allocation

**Figure V-17**




The allocation of cost by type of improvement and by customer group depends on the limit on rationing during a drought or supply outage, which determines the amount of new storage needed. The existing policy includes a 39% limit on rationing.

## Financial Impact of Additional Storage

Figure V-18

| | 100KAF | 145 KAF |
|---|---|---|
| Rate impact bond debt life[1] | $0.048/CCF | $0.063/CCF |
| Rate impact debt life[2] Percent of average monthly water bill | 1.3% | 1.6% |
| Average SCC increase[3,4] | $285/100 gpd | $350/100 gpd |
| Region 1 | $855 | $1055 |
| Region 2 | $990 | $1230 |
| Region 3 | $990 | $1230 |
| Region 4 | $990 | $1230 |
| Region 5 | $1135 | $1405 |
| Region 6 | $1700 | $2110 |
| Region 7 | $1990 | $2460 |

(1)CCF is 100 cubic feet or 748 gallons of water.

(2)The average bill is based on a monthly use of 13 CCF.

(3)The Service Capacity Charge (SCC) depends on the average use per person in an area which varies from 300 gpd in Region 1 to 700 gpd in Region 7.

(4)SCC increase is lower than average in 1989 and higher than average in 2020.

## Proposed Water Supply Management Program

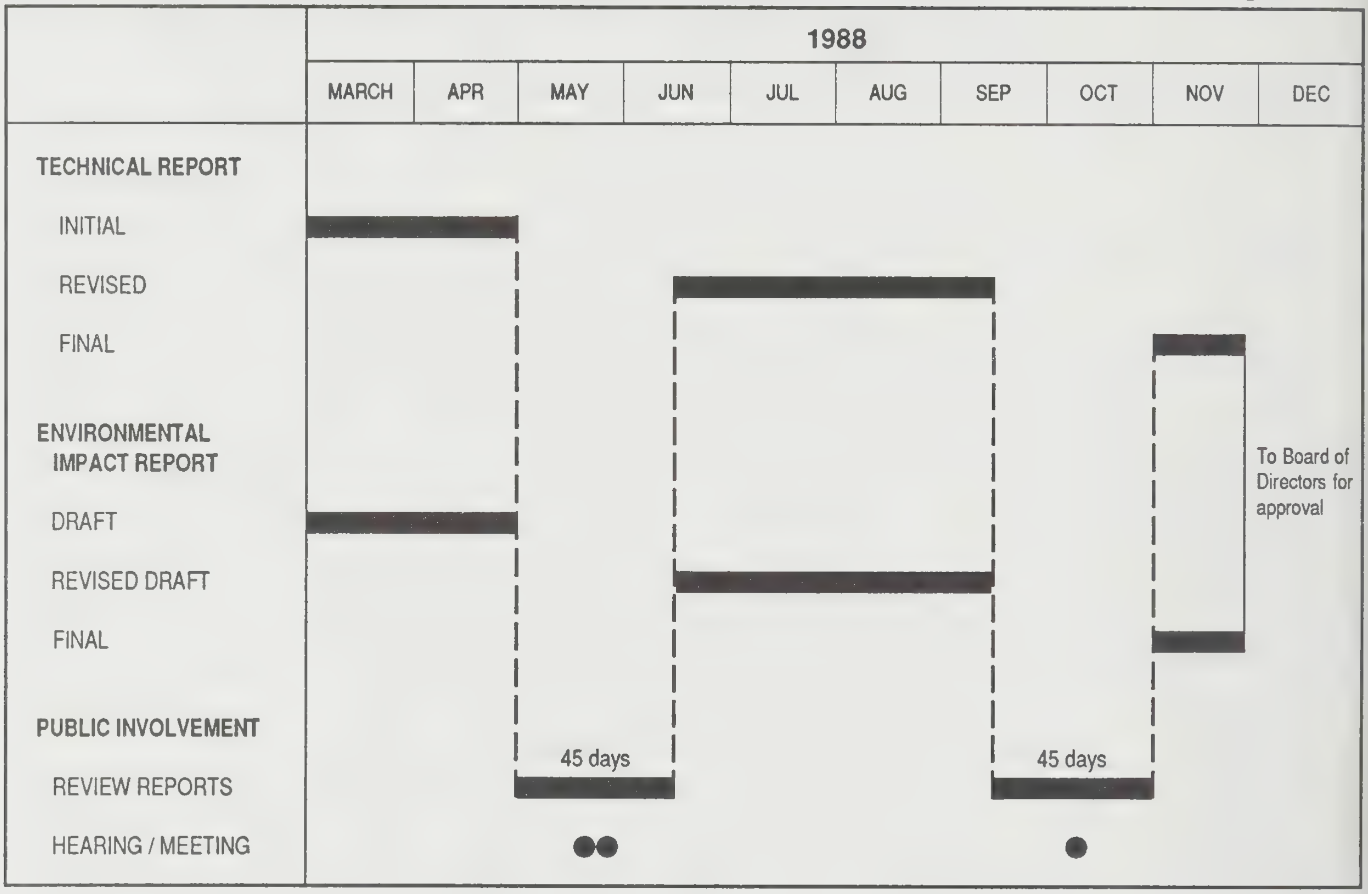
Figure V-19

| OBJECTIVE | PROGRAM | ACTION | COST | TIMING |
|---|---|---|---|---|
| **SECURITY:** Protect against floods and earthquakes | Water Banking* (additional terminal storage) | Construct new terminal reservoir (145,000 acre-feet) | $152 to $185 million | In service in 1995 |
| | Levee and Foundation Improvements in the Delta | Continue repair, maintenance and upgrading of levees | $8 million | Complete by 1991 |
| | | Preliminary engineering of levee reinforcement and pipe-line supports | $2 million | Complete by 1995 |
| **SHORTAGE:** Supply to meet water demands in dry periods | Water Banking* (additional terminal storage) | Construct new terminal reservoir (145,000 acre-feet) | $152 to $185 million | In service in 1995 |
| | Water Conservation | Implement additional measures and continue existing program | $0.8 million per year | Implement immediately |
| **SAFETY AND HEALTH:** Maintain high quality water | Water Reclamation | Develop new reclamation projects and continue existing program | $15 million | Implement immediately |
| | Enhance Watershed Lands of Terminal Reservoirs | Purchase additional watershed lands to the ridgelines | $20 million | Complete by 1995 |
| | Treatment Improvement Program | Continue treatment plant modernization and improvements | $35 million | Complete by 1992 |

*The proposed program includes revision of EBMUD's Water Supply and Availability Policy to change the limit on rationing during an extended outage or drought shortage from 39% to 25%, which is the basis of the proposed terminal reservoir capacity and reduces the hardship on EBMUD's customers.

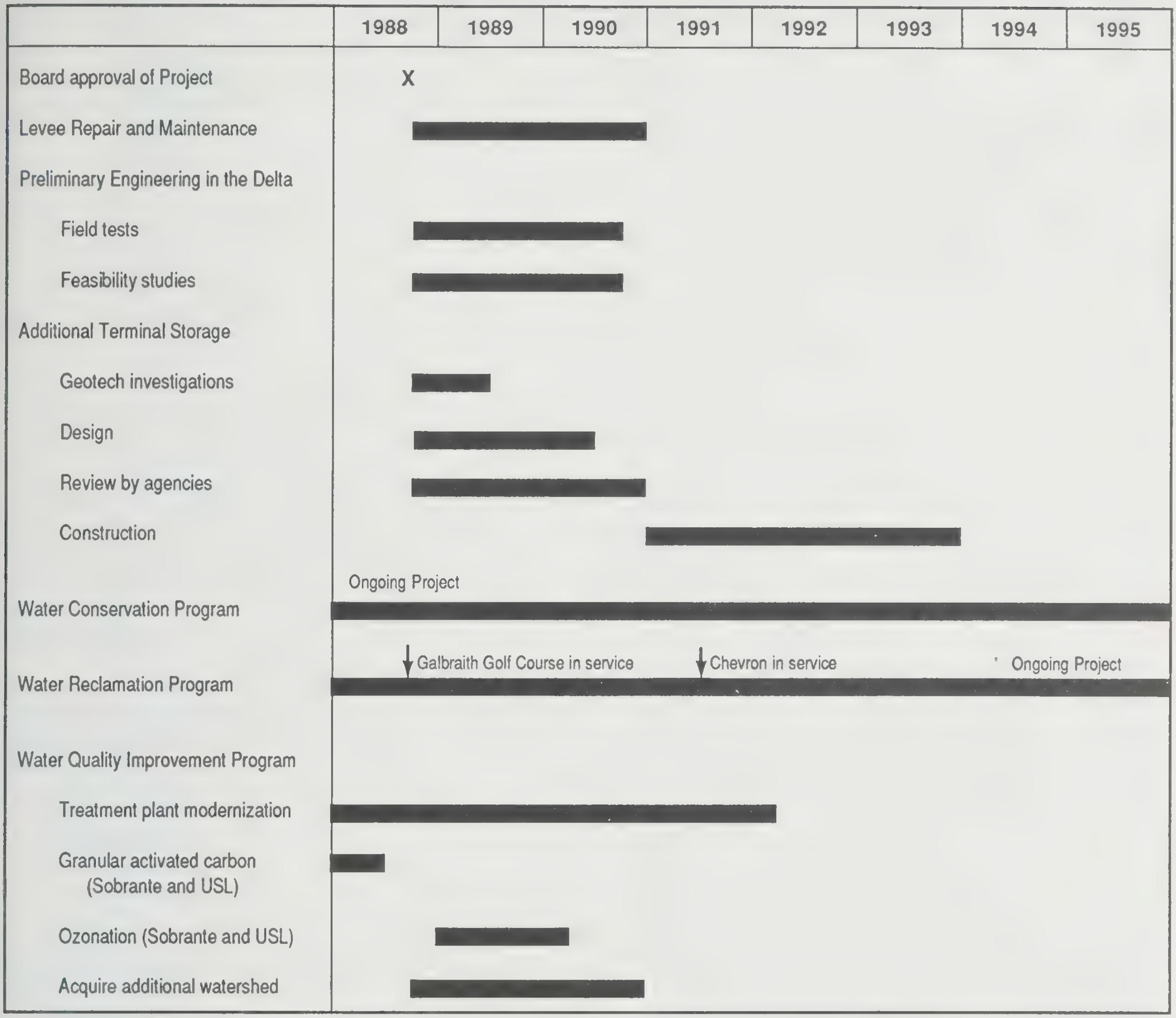
## Water Supply Management Program Process

Figure V-20



## Water Supply Management Program Implementation Schedule

Figure V-21



# Chapter VI
# Selection of Terminal Reservoir Site

## WATER BANKING

Chapter V concludes that for both security and shortage needs, water banking--additional terminal storage--appears to be the most feasible and cost-effective solution.

This chapter discusses the alternative sites and related pipelines and pumping plants for a new reservoir and the site selection if additional terminal storage is constructed.

## DEVELOPMENT OF SITE ALTERNATIVES

### Initial Investigation

Consideration was given to 26 potential reservoir sites throughout the service area, as well as to raising EBMUD's existing dams, and removing silt from existing reservoirs.

None of EBMUD's existing dams was designed with provisions to increase the capacity of the reservoirs in the future. To increase the volume of EBMUD's existing reservoirs, by 100,000 to 145,000 acre-feet, the reservoirs would require draining before the construction work could be performed. Raising Upper San Leandro Dam would cause flooding of the City of Moraga unless a second dam were built. Raising San Pablo Dam would cause flooding of Orinda Filter Plant, JFK University, San Pablo Dam Road, and the City of Orinda. It would also cause inundation of the downstream face of Briones Dam. Raising Briones Dam would require reconstruction of the existing dam because of its non-symmetrical distribution of core material. Chabot and Lafayette Reservoirs which have existing capacities of 10,300 and 4,200 acre-feet have very small watersheds. To increase their capacities by 100,000 to 145,000 acre-feet would not be feasible. The cost and the temporary loss of supply during construction would not warrant further consideration of raising any of the existing dams.

Figure VI-1 identifies the locations of the 26 dam sites that were identified and evaluated. The sites can be grouped into three general areas: West Contra Costa County, South Alameda County, and East Contra Costa County. To reduce the number of alternatives to be retained for final evaluation, the alternatives were screened based on capital cost, land use, and operational considerations.

Capital costs included the cost of the dam, appurtenances, and conveyance facilities. Land use considerations included the potential impact on housing, transport, and public use facilities. Operational considerations included the reservoir location relative to the District's water supply and distribution system.

Figure VI-2 summarizes the sizes and capital costs of the reservoir alternatives and the reasons for their rejection or retention for final evaluation. The Pinole site is clearly the most cost effective of the sites in West Contra Costa County. Many sites in East Contra Costa County had also been studied by the Contra Costa Water District, and the Los Vaqueros site is clearly the most cost effective of the sites in this region. In South Alameda County, the San Leandro and Buckhorn sites appear to be the most cost effective. However, the San Leandro site has a major operational drawback. San Leandro Reservoir would operate in conjunction with Upper San Leandro (USL) Reservoir and would be capable of serving only USL filter plant. In addition, San Leandro Reservoir

would contain a large amount of unusable storage (40 percent of the total volume) below the minimum water surface elevation needed to operate USL Filter Plant.

Comparing all the sites to each other on the criteria above, the alternatives selected for final evaluation were:

- Pinole
- Buckhorn
- Los Vaqueros

The site locations are shown in Figure VI-3.

### Final Site Evaluation

Figure VI-4 summarizes the final evaluation of Pinole, Buckhorn, and Los Vaqueros Reservoirs. Details of the costs may be found in Appendix G.

### PINOLE RESERVOIR

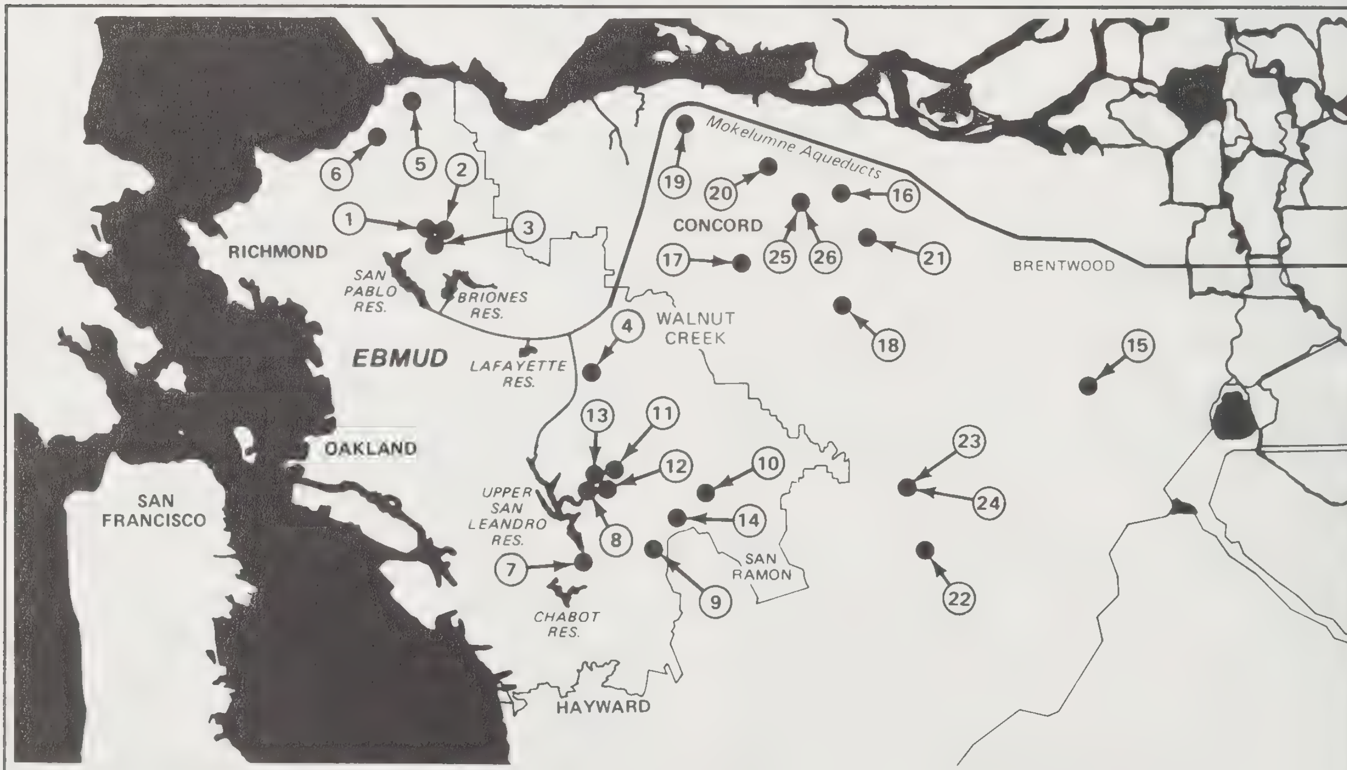
Pinole Reservoir, shown in Figure VI-5, is located on Pinole Creek between Pinole and Sobrante Ridges just northeast of San Pablo Reservoir and southeast of the City of Pinole. Reservoir sizes under consideration range from 31,000 acre-feet to 50,000 acre-feet, most of which would be usable storage. Spillway crest elevations range from 313 feet to 340 feet, and dam heights range from 150 feet to 180 feet. A preliminary study for the smaller dam was completed in 1958.

| Spillway Crest Elevation (Feet) | Dam Height (Feet) | Reservoir Capacity (KAF) | Usable Volume (KAF) |
|---|---|---|---|
| 313 | 327 | 31,000 | 23,000 |
| 340 | 355 | 50,000 | 42,000 |

A chute spillway, located on the right abutment, would discharge into Pinole Creek downstream from

## Potential Reservoir Sites

Figure VI-1




| | | | | | |
|---|---|---|---|---|---|
| 1 | Pinole | 10 | Bollinger Canyon | 19 | Nichols |
| 2 | Upper Pinole A | 11 | Upper Kaiser | 20 | Bailey Road |
| 3 | Upper Pinole B | 12 | Kaiser | 21 | Morning Side |
| 4 | Tice Valley | 13 | Upper Buckhorn | 22 | Alamo Creek |
| 5 | Canada del Cierbo | 14 | Bolinas | 23 | High Tassajara |
| 6 | Rodeo Canyon | 15 | Los Vaqueros | 24 | Low Tassajara |
| 7 | San Leandro | 16 | Sidney Flat | 25 | High Kirker |
| 8 | Buckhorn | 17 | Curry Canyon | 26 | Low Kirker |
| 9 | Cull Canyon | 18 | Mitchell Canyon | | |

## Preliminary Reservoir Site Evaluation

Figure VI-2

| RESERVOIR SITE | TOTAL STORAGE KAF | TOTAL COST* $ Millions | UNIT COST $ Millions/KAF | REASON(S) FOR REJECTION |
|---|---|---|---|---|
| **WEST CONTRA COSTA COUNTY** | | | | |
| Pinole | 50.0 | 65 | 1.3 | Retained for final evaluation |
| Upper Pinole A | 37.0 | 70 | 1.9 | a |
| Upper Pinole B | 46.0 | 90 | 2.0 | a |
| Tice Valley | 60.0 | 120 | 2.0 | a,b |
| Canada del Cierbo | 14.2 | 180 | 12.7 | a,b |
| Rodeo Canyon | 15.0 | N/A | N/A | b |
| **NORTH ALAMEDA COUNTY - SOUTH CONTRA COSTA COUNTY** | | | | |
| San Leandro | 68.0 | 80 | 1.2 | d |
| Buckhorn | 145.0 | 165 | 1.1 | Retained for final evaluation |
| Cull Canyon | 50.0 | 110 | 2.2 | a,b |
| Bollinger Canyon | 50.0 | 165 | 3.3 | a,b |
| Upper Kaiser | 36.0 | 170 | 4.7 | a |
| Kaiser | 11.0 | 65 | 5.9 | a |
| Upper Buckhorn | 14.0 | 60 | 4.3 | a |
| Bolinas | 56.0 | 200 | 3.6 | a |
| **EAST CONTRA COSTA COUNTY** | | | | |
| Los Vaqueros(1) | 77.0 | 130 | 1.7 | Retained for final evaluation |
| Sidney Flat | 62.0 | N/A | N/A | b,c |
| Curry Canyon | 50.0 | 115 | 2.3 | a |
| Mitchell Canyon | 50.0 | 200 | 4.0 | a |
| Nichols | 9.0 | N/A | N/A | c |
| Bailey Road | 3.0 | N/A | N/A | c |
| Morning Side | 15.0 | N/A | N/A | c |
| Alamo Creek | 32.0 | 190 | 5.9 | a |
| High Tassajara | 38.0 | 220 | 5.8 | a |
| Low Tassajara | 28.0 | 180 | 6.4 | a |
| High Kirker | 50.0 | 185 | 3.7 | c |
| Low Kirker | 26.0 | 80 | 3.1 | c |

NOTES:

(1)One joint project with Contra Costa Water District

a Unit cost greater than that of comparable site(s)

b Reservoir would displace major housing, transport or public use facilities.

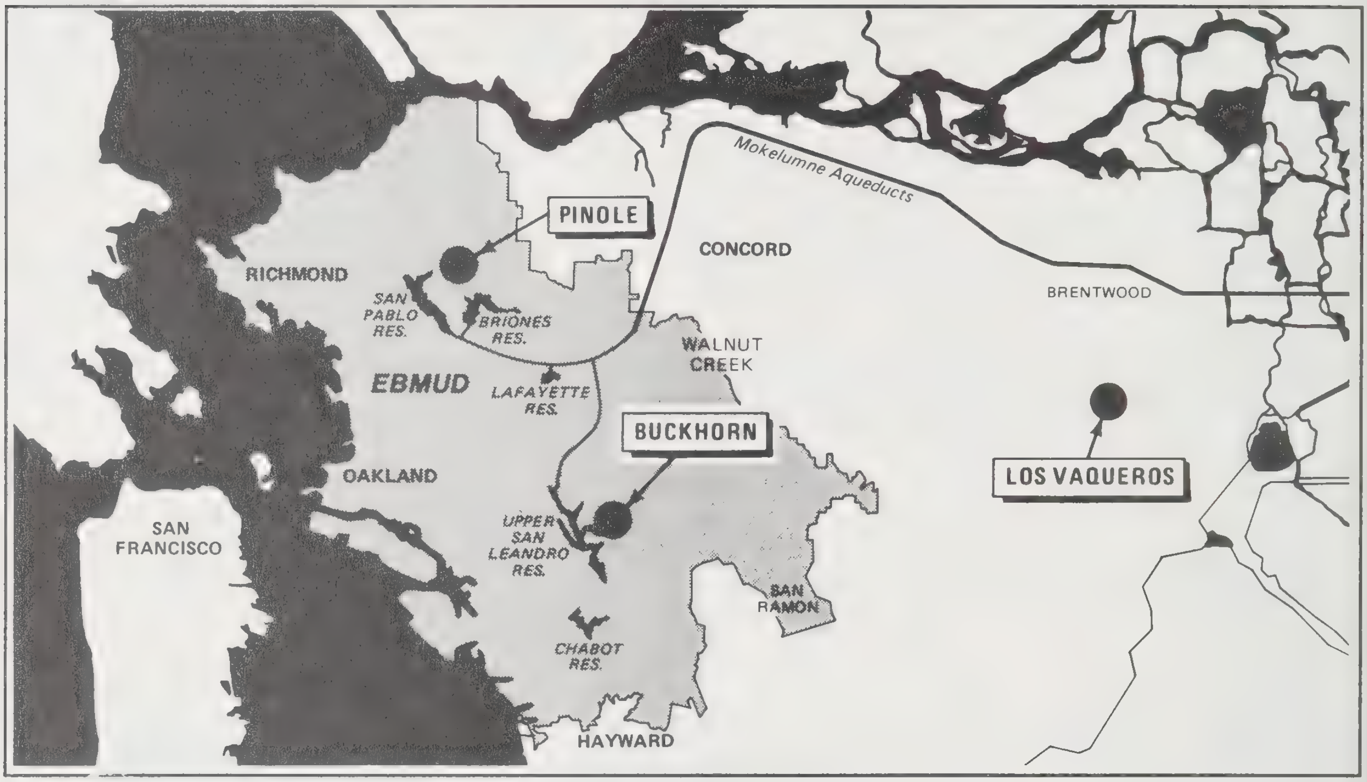
c Studied and rejected by Contra Costa Water District and addressed in Los Vaqueros EIR.

d Reservoir location not compatible with distribution system.

*Total cost in 1987 dollars.

Alternative Reservoir Sites

Figure VI-3




the dam. An inlet-outlet tower would be located near the left abutment of the dam and would serve three functions: (1) flow into Pinole Reservoir; (2) releases to San Pablo Reservoir or Sobrante Filter Plant; and (3) reservoir blowoff to Pinole Creek. A pumping plant would not be required for the smaller reservoir because it would operate in conjunction with San Pablo Reservoir, which has the same spillway crest elevation.

For the larger reservoir, the pumping plant would be located just below San Pablo Dam, southwest of San Pablo Creek and the Sobrante Raw Water Aqueduct. Water would be pumped from the existing San Pablo Reservoir through the Sobrante Aqueduct, through 1,800 feet of new 72-inch pipe, and then 6,800 feet of tunnel to Pinole Reservoir. This is the proposed aqueduct alignment for Pinole and is shown in Figure VI-5. The Pinole Pumping Plant is located on District property at an elevation low enough for successful operation. This would allow 9 months to initially fill the reservoir. This site has better access than alternative locations and thereby a lower construction cost. Figure VI-6 shows the hydraulic operation for this preferred pipeline and tunnel alignment.

While many pipeline and tunnel alignments were considered, the most feasible alternatives are shown in Figure VI-7 and summarized in Figure VI-8.

The water quality in Pinole Reservoir is difficult to assess prior to construction. The water quality will depend on several factors, such as source of water, soil characteristics of the watershed, depth of reservoir, and residence time. Pinole Reservoir would be filled from San Pablo Reservoir and would therefore require full treatment similar to that provided for water from San Pablo Reservoir. Pinole Reservoir, with a maximum depth of about 180 feet, is a relatively shallow reservoir and would therefore be more susceptible to taste and odor problems than a deeper reservoir would be.

## BUCKHORN RESERVOIR

Buckhorn Reservoir is located about 1-½ miles north of USL Dam in a narrow arm of USL Reservoir. Five alternative dam axis locations were evaluated, and the location shown in Figure VI-9 was selected because (1) it has the smallest dam section, (2) it retains the largest reservoir capacity, and (3) it is founded entirely on Painoche formation, which is competent bedrock material requiring minimal foundation treatment. Reservoir sizes under consideration range from 80,000 acre-feet to 145,000 acre-feet with dam heights ranging from 305 feet to 370 feet. Geographically, Buckhorn Reservoir has the advantage of being able to serve any of the District's filter plants by gravity. The dam would be an earthfill embankment with a

## Comparison of Terminal Reservoir Alternatives

**Figure VI-4**

| ALTERNATIVE | STORAGE VOLUME | | CAPITAL COSTS[1] | | INCREASE IN AVAILABLE SUPPLY[2] (MGD) | FILLING TIME[3] (Months) | DEFICIENCY[4] During 13 Mo. Outage (%) | WATER QUALITY | ENVIRONMENTAL IMPACTS[5] |
|---|---|---|---|---|---|---|---|---|---|
| | Total Volume (KAF) | Usable Volume (KAF) | Total Cost ($ Mill) | Unit Costs ($ Mil/KAF Usable Volume) | | | | | |
| PINOLE | | | | | | | | Would be filled with San Pablo Reservoir water and will require full treatment similar to San Pablo Reservoir water. | Impacts on riparian habitat. Possible disturbance to rare and endangered species of Aleutian Canada Goose. Temporarily increased truck traffic on local roads, particularly on Castro Ranch Road and Pinole Valley Road. |
| 313' | 29 | 25 | $ 55 | $2.20 | 15 | 7 | 62 | | |
| 340' | 50 | 44 | $ 65 | $1.48 | 23 | 9 | 56 | | |
| | (EBMUD's portion) | | | | | | | | |
| LOS VAQUEROS[6] | | | | | | | | A viable alternative for EBMUD only if Mokelumne River water or equally high quality water is used to fill it. | Impacts on riparian habitat. Temporary increase in truck traffic on local roads, particularly on Vasco Road and Walnut Boulevard. |
| 560' | 155 | 143 | $200 | $1.38 | 66 | 18 | 25 | | |
| BUCKHORN | | | | | | | | Protected watershed. Would be filled with Mokelumne River water. Direct filtration only unless fed into Upper San Leandro or San Pablo Reservoirs. | Impacts on riparian habitat. Temporary increase in truck traffic on local roads, particularly on Redwood Road and Miller Road. |
| 680' | 80 | 78 | $115 | $1.47 | 32 | 23 | 45 | | |
| 745' | 145 | 143 | $170 | $1.18 | 66 | 18 | 25 | | |

**NOTES:**

(1) Costs shown are in 1988 dollars.

(2) Numbers are based on the maintenance of 120-day Standby Supply for outages during all hydrologic conditions including very dry years. Assumes 25% reduction in demand in dry years, and 2020 demands.

(3) Indicates time needed for terminal reservoirs to initially fill reservoirs at demand of approximately 230 MGD in the year 1996.

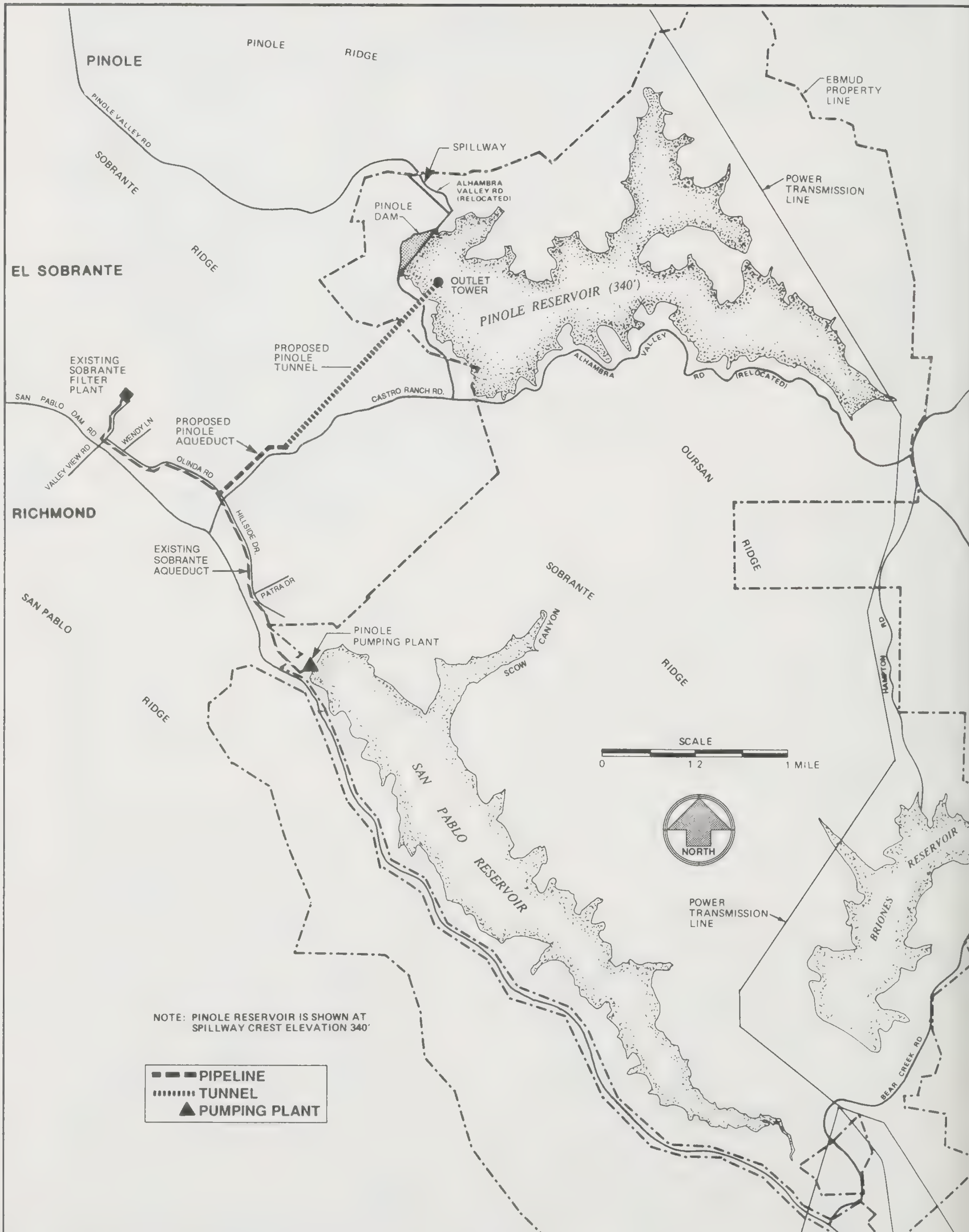
(4) Deficiencies are based on year 2020 projected demand of 270 MGD.

(5) Detailed assessment of environmental impacts of Buckhorn (745'), Los Vaqueros (560') and Pinole (340') are made in the Draft EIR.

(6) Costs would vary; costs shown are based on one possible joint project with Contra Costa Water District.

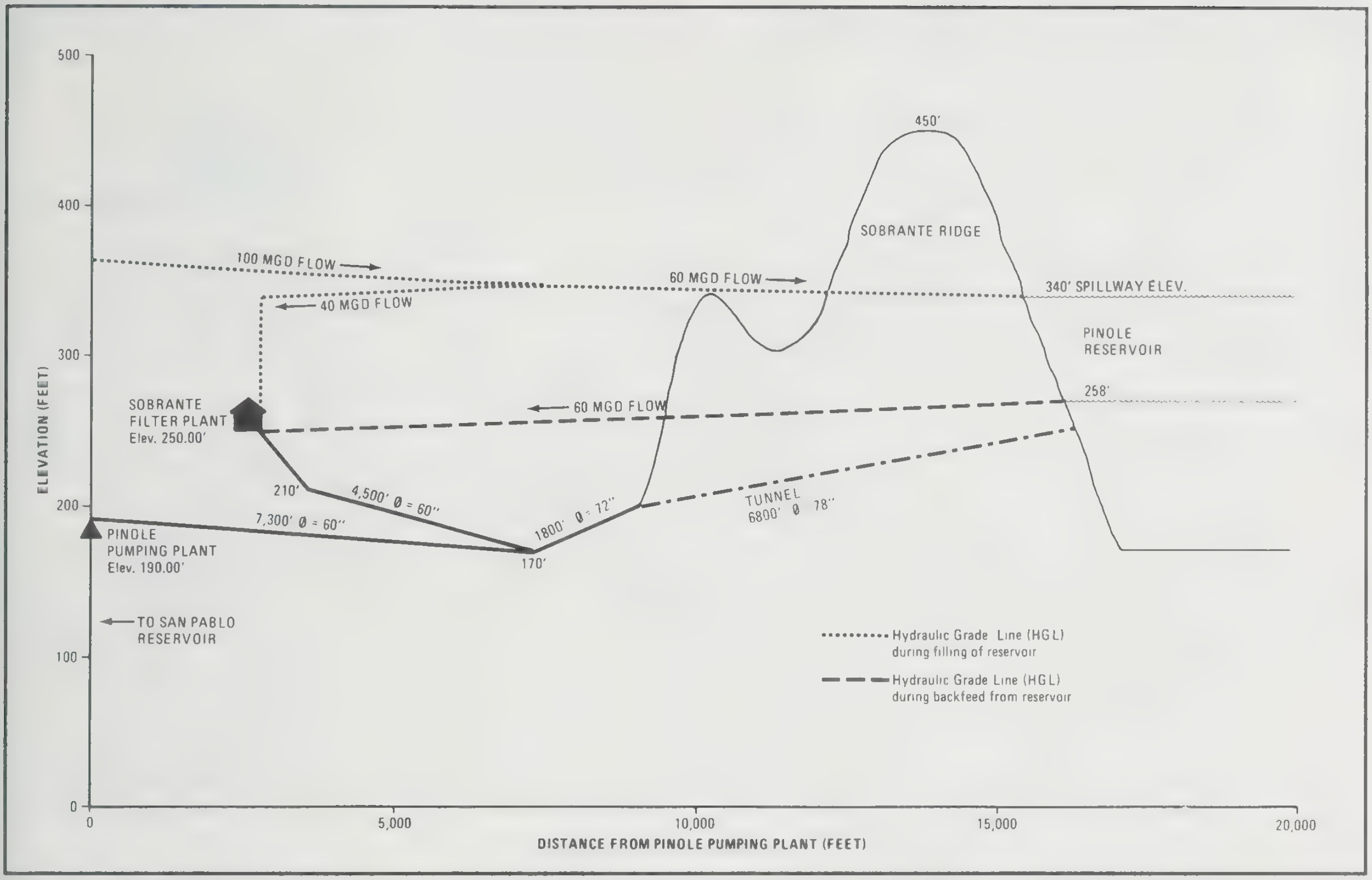
# Pinole Reservoir (340')
# Proposed Aqueduct Alignment

Figure VI-5



# Operation of Pinole Reservoir

Figure VI-6




spillway approximately 30 feet wide on the left abutment.

| Spillway Crest Elevation (Feet) | Dam Height (Feet) | Reservoir Capacity (KAF) | Usable Volume (KAF) |
|---|---|---|---|
| 680 | 305 | 80 | 78 |
| 735 | 360 | 134 | 132 |
| 745 | 370 | 145 | 143 |

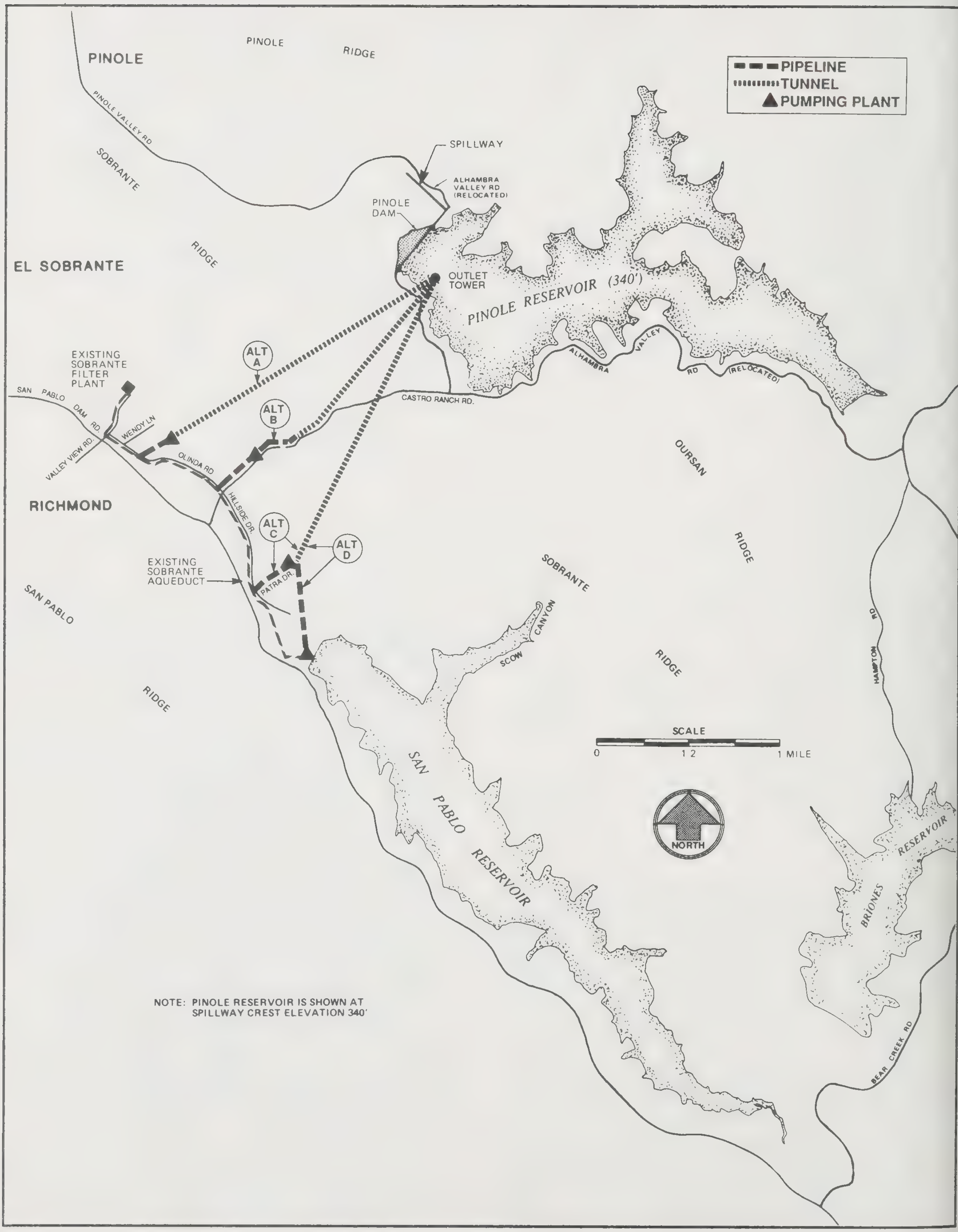
A Buckhorn dam with spillway crest elevation above 680 feet would require, in addition to the main dam, two small dikes on the ridge south of the proposed reservoir. At spillway crests below 735 feet, the dikes may be composed of earthfill material. At spillway crests above 735 feet, the dikes would be constructed of rockfill or rolled compacted concrete.

The reservoir would be filled via the existing Moraga Aqueduct and the proposed pumping plant would be built near St. Mary's College in Moraga. The plant would take suction from the Moraga Aqueduct and deliver approximately 105 MGD through 23,000 feet of new 84-inch pipe, then through 6,000 feet of 90-inch tunnel leading to the reservoir. A flow rate of 105 MGD can be achieved by adding a pump to the existing spare barrel at Moraga Pumping Plant. The proposed aqueduct alignment is shown in Figure VI-9. Figure VI-10 shows the hydraulic operations for this proposed pipeline and tunnel alignment.

Five tunnel alignments were evaluated in the Geologic Reconnaissance Study (June 1987) (see Appendix J). The preferred location passes through only one geologic formation, the Claremont formation. The other alignments cross up to four geologic units and a fault zone and traverse beneath thin ground cover. The portals of these alternative alignments also lie in the base of a landslide area. Two alternative alignments to reduce the cost of shortening the length of tunnel were also considered. The first alignment evaluated a 72-inch pipeline route from St. Mary's College (570') to the reservoir with no tunnel. A pumping plant would be necessary to pump water over a hill at elevation 1100'. Another pumping plant would be required at Buckhorn Reservoir to pump water back over the hill and into the Lafayette Aqueducts. Because of the additional pumping requirements associated with a pipeline alignment, this alternative proved to be more expensive and was eliminated from further consideration. The second alignment, extending along USL Reservoir, was eliminated from further consideration because it did not shorten the tunnel enough to reduce cost

## Pinole Reservoir (340')
## Alternative Aqueduct Alignments

Figure VI-7



## Pinole Aqueduct Route Alternatives

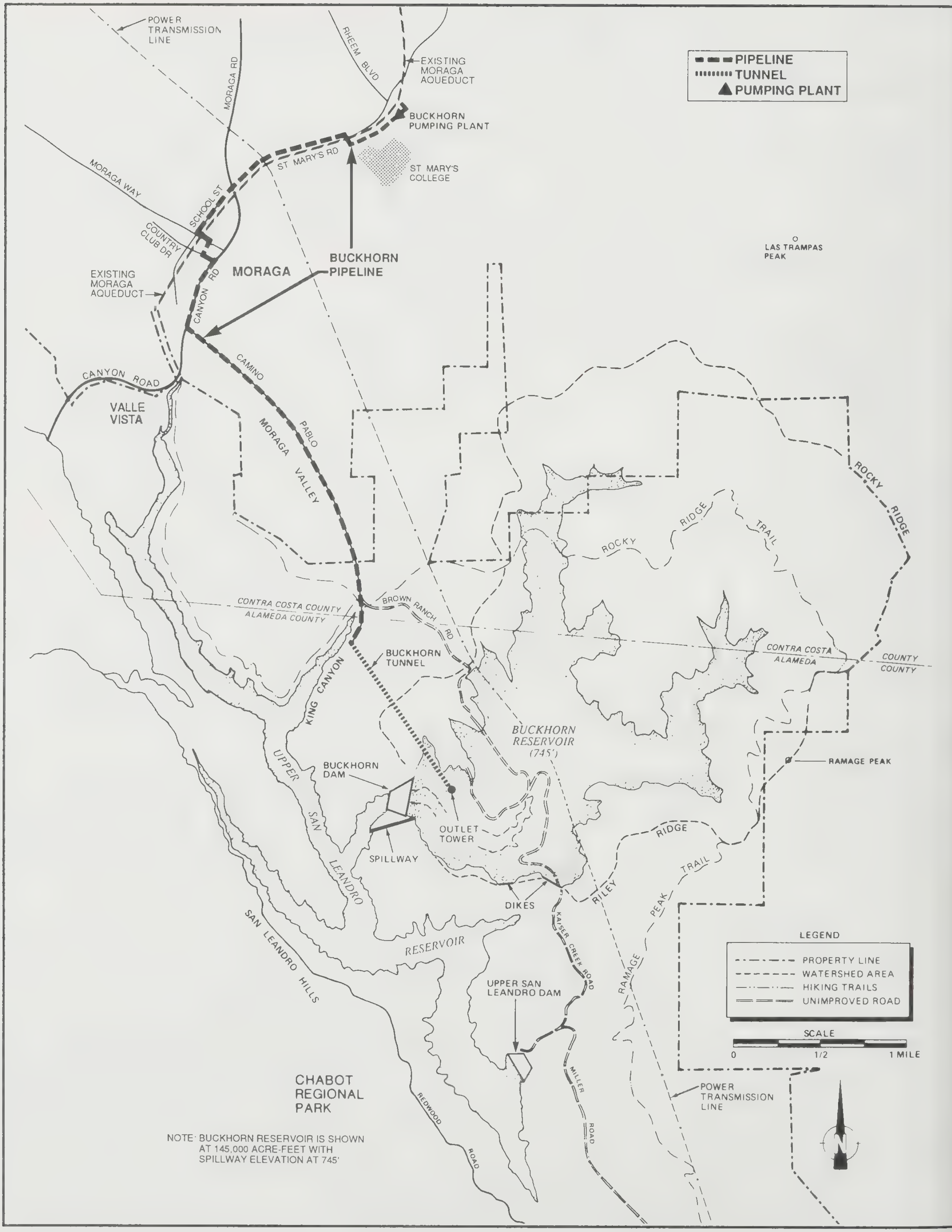
Figure VI-8

| ALTERNATIVE | COSTS: AQUEDUCT ($M) | COSTS: PUMPING PLANT ($M) | COSTS: TOTAL CAPITAL ($M) | COSTS: FILLING ($M) | COSTS: O&M* ($M) | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|---|---|---|
| **AS PROPOSED IN DEIR**<br>New pipeline from Sobrante Aqueduct along Castro Ranch Road. New tunnel from Castro Ranch Road to outlet tower.<br>Pipeline: 1,800' (6' D)<br>Tunnel: 6,800' (6.5' D)<br>Pumping Plant: 2,500 HP | 16 | 3 | 19 | 4 | 7 | • Pumping plant. located away from development.<br>• Shorter tunnel.<br>• Least cost.<br>• Pipeline avoids slide prone area. | • Tunnel under Carriage Hills Development.<br>• Tunnel goes through several geological formations; tunnel crosses Pinole Fault Zone.<br>• Tunnel has shallow cover under the Sobrante Ridge Reserve. |
| **ALTERNATIVE A**<br>New pipeline from Sobrante Aqueduct to pumping plant near Olinda Road. New tunnel from the pumping plant to outlet tower.<br>Pipeline: 1,200' (6' D)<br>Tunnel: 8,500' (6.5' D)<br>Pumping Plant: 2,530 HP | 19 | 3 | 22 | 4 | 7 | • Shortest pipeline. | • May require condemnation of properties for construction of pipeline.<br>• Tunnel goes through several geological formations; tunnel crosses Pinole Fault Zone<br>• Tunnel goes underneath two developed areas and Sobrante Ridge Reserve. |
| **ALTERNATIVE B**<br>New pipeline from the Sobrante Aqueduct along Castro Ranch Road. New tunnel to outlet tower.<br>Pipeline: 1,800' (6' D)<br>Tunnel: 6,800' (6.5' D)<br>Pumping Plant: 2,500 HP | 16 | 3 | 19 | 4 | 7 | • Shorter tunnel.<br>• Least cost.<br>• Pipeline avoids slide prone area. | • Pumping plant located near development.<br>• Tunnel goes through several geological formations; tunnel crosses Pinole Fault Zone.<br>• Tunnel has shallow cover under the Sobrante Ridge Reservoir.<br>• Tunnel goes under Carriage Hills Development. |
| **ALTERNATIVE C**<br>New pipeline from the Sobrante Aqueduct along Patra Drive to a new pumping plant. New tunnel from the pumping plant to the outlet tower.<br>Pipeline: 2,000' (6' D)<br>Tunnel: 8,500' (6.5' D)<br>Pumping Plant: 2,060 HP | 20 | 3 | 23 | 4 | 7 | • Pipeline avoids slide prone area.<br>• Deep tunnel cover. | • Tunnel under Carriage Hills Development.<br>• Tunnel goes through several geological formations; tunnel crosses Pinole Fault Zone. |
| **ALTERNATIVE D**<br>New pipeline from base of San Pablo Dam Road to end of Patra Road. New tunnel from pumping plant on Patra Road to the outlet tower.<br>Pipeline: 2,600' (6' D)<br>Tunnel: 8,500' (6.5' D)<br>Pumping Plant: 1,770 HP | 20 | 3 | 23 | 4 | 7 | • Pumping plant located in remote area.<br>• Deep tunnel cover. | • Long tunnel.<br>• Tunnel goes under Carriage Hills Development.<br>• Tunnel goes through several geological formations; tunnel crosses Pinole Fault Zone.<br>• Pipeline in slide prone area. |

*Present Worth Cost. Includes engineering, administration and 10% contingencies.

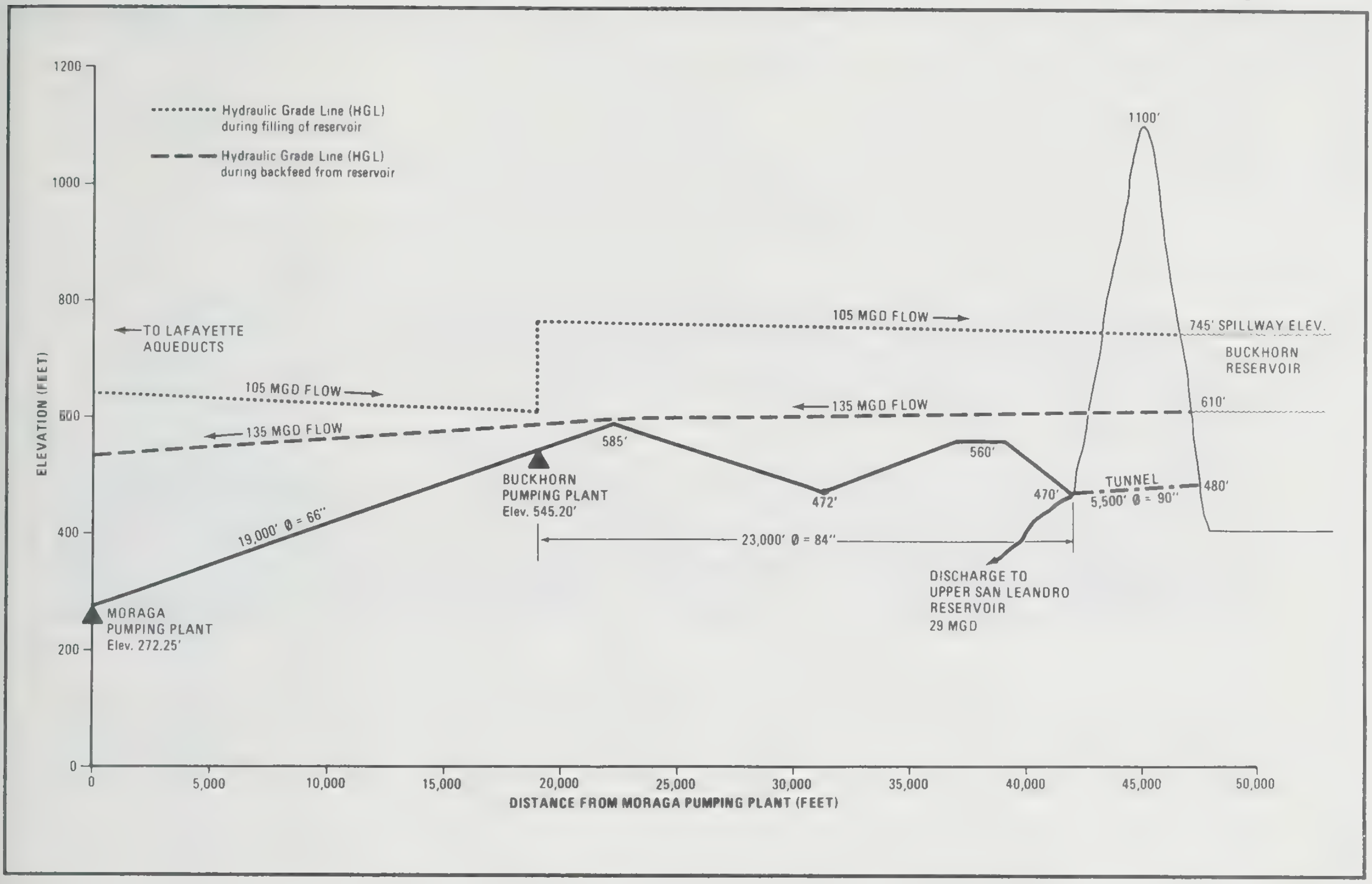
# Buckhorn Reservoir (745')
# Proposed Aqueduct Alignment

Figure VI-9



## Operation of Buckhorn Reservoir

Figure VI-10




significantly. In addition, the portal of this alignment would not provide adequate space for a tunnel staging area.

When necessary, water from Buckhorn Reservoir would be delivered by gravity back through the tunnel, the new pipeline, and the Moraga Aqueduct to the District's filter plants. District operation of the reservoirs during a 13-month outage is shown in Figure VI-11.

While many pipeline and tunnel alignments were evaluated, the most feasible alternatives are shown in Figure VI-12 and Figure VI-13 summarized in Figure VI-14.

The water quality in Buckhorn Reservoir is difficult to assess prior to construction. However, there are two factors which indicate that favorable water quality conditions will occur in the reservoir. First, the reservoir would be filled with high quality Sierra water directly off the Mokelumne Aqueducts. Second, with a maximum depth of 370 feet, Buckhorn Reservoir is relatively deep and would therefore be less susceptible to taste and odor problems.

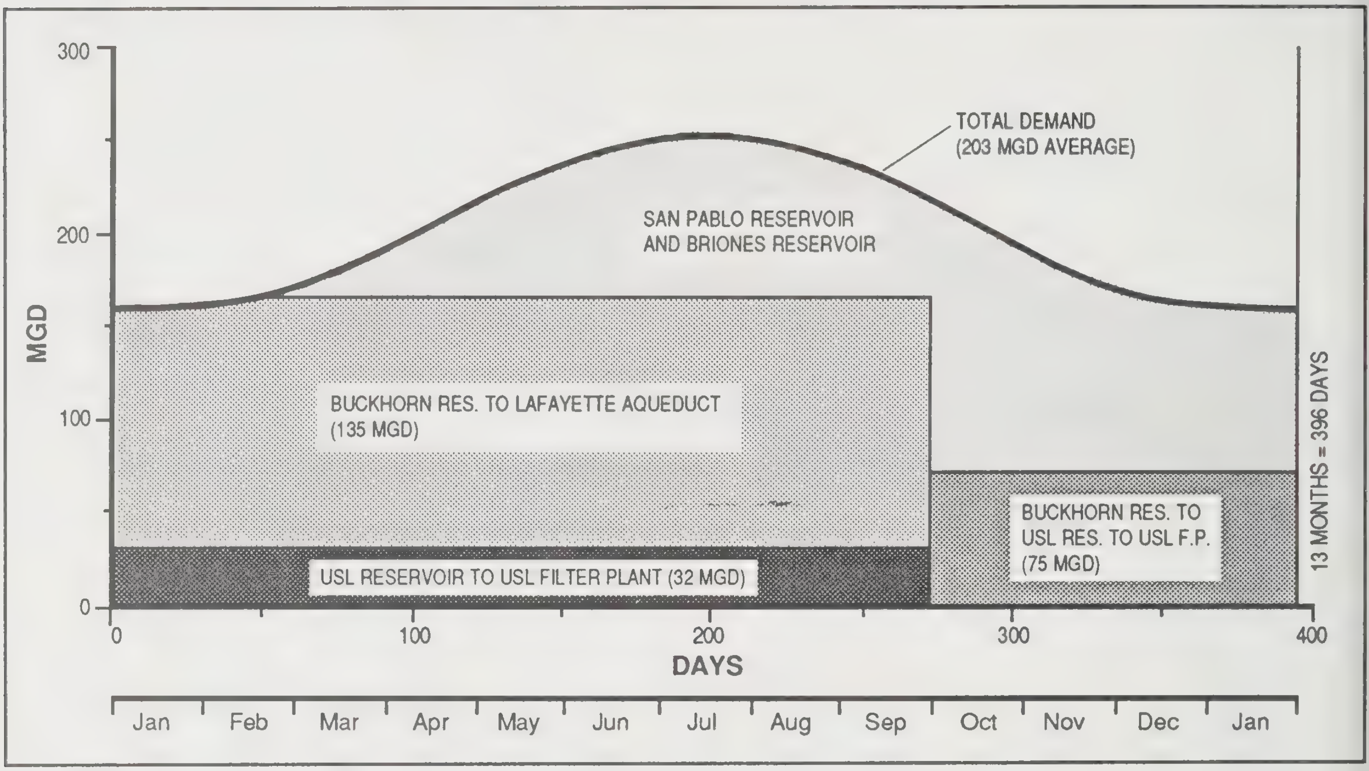
## LOS VAQUEROS RESERVOIR

The Los Vaqueros site, shown in Figure VI-15, is located on the western side of the Delta, approximately nine miles south of the City of Brentwood. The reservoir would store water from the Mokelumne Aqueducts via a connection near Brentwood. This site has been evaluated by the State of California for the State Water Project and by the Federal government for the Central Valley Project, as well as Contra Costa Water District (CCWD). CCWD is in the process of acquiring the property and developing a specific reservoir project for use in its system and is interested in a joint project with EBMUD and other agencies. The draft EIR on Stage 1, which covers land acquisition for the Los Vaqueros/Kellogg Project was completed in May 1986. The size of Los Vaqueros Reservoir could range from 50,000 to 1,000,000 acre-feet. The draft EIR for Stage 2 which covers the environmental impacts of constructing Los Vaqueros is anticipated after November 1988.

To be consistent with EBMUD's objective to serve high quality water and compatible with EBMUD's

## Use of Terminal Storage During Outages or Drought

**Figure VI-11**




existing treatment facilities, a joint project with CCWD would require storage of Sierra water in Los Vaqueros. Currently, CCWD takes its water supply from the Delta at Rock Slough. Delta water quality, especially temperature, turbidity, and algal activity, is subject to significant fluctuations. During periods of low runoff, Delta water quality can fluctuate depending upon Delta inflows, Delta exports, and Delta outflow to San Francisco Bay. CCWD has experienced degradation in the quality of its Delta water supply in the form of high chloride levels due to low runoff of fresh water into the Delta. CCWD is presently preparing an EIR to purchase EBMUD's surplus Mokelumne water on an interruptible basis in an effort to improve their water quality at these times.

One possible joint project with CCWD would be a reservoir that provided a minimum of 144,000 acre-feet of usable storage for EBMUD. As shown in the following table, the total reservoir size would have to be approximately 265,000 acre-feet to meet both CCWD's and EBMUD's needs. It is estimated that approximately 13,000 acre-feet would be unusable storage.

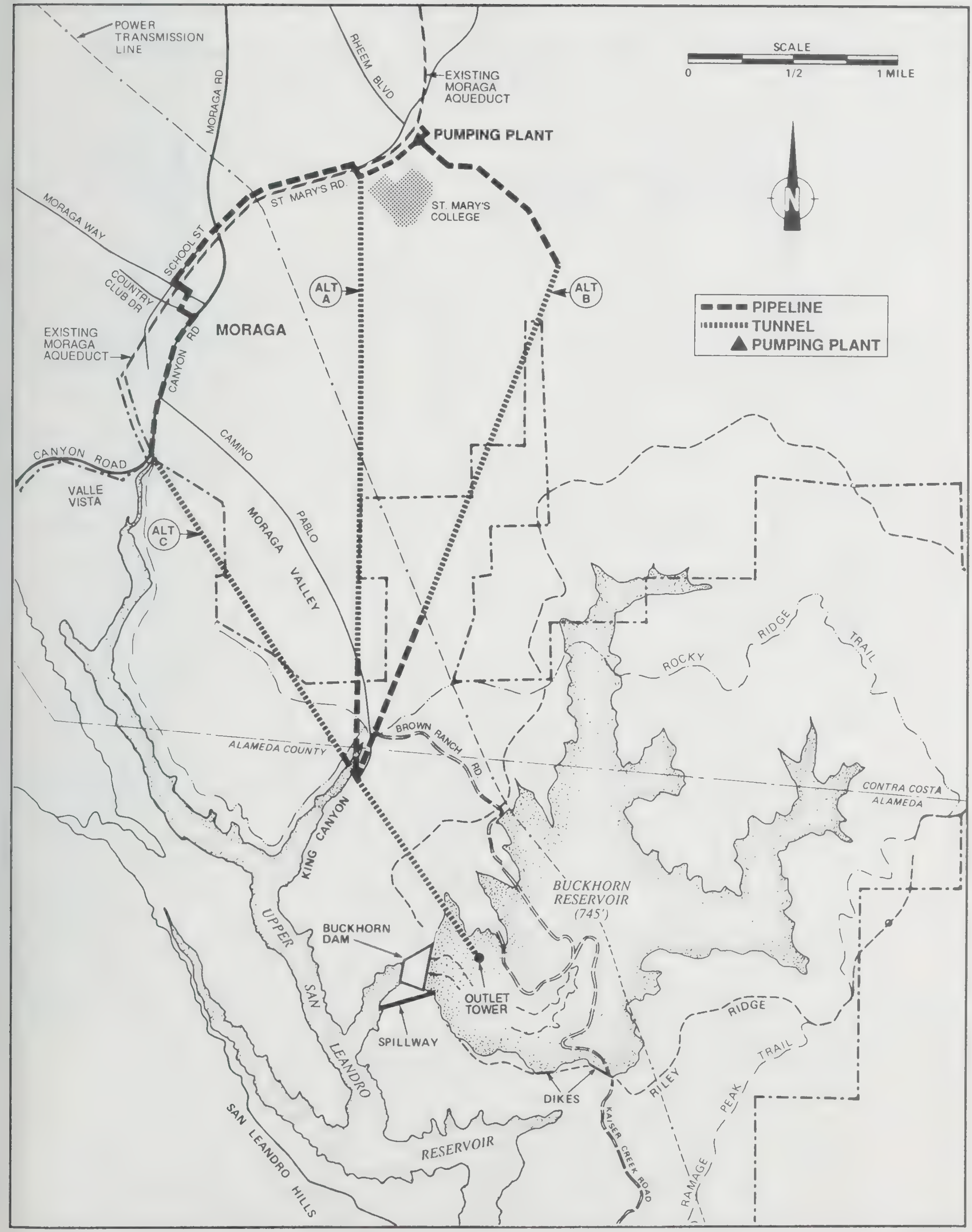
| Storage Purpose | CCWD | EBMUD | Total |
|---|---|---|---|
| Usable Storage | 100 KAF | 143 KAF | 243 KAF |
| Flood Control | 4 KAF | 4 KAF | 8 KAF |
| Unusable Storage | 6 KAF | 7 KAF | 13 KAF |
| TOTAL | 110 KAF | 155 KAF | 265 KAF |

A reservoir with 265,000 acre-feet of storage would have an approximate spillway crest elevation of 560 feet. At this elevation, only one main embankment, about 270 feet high, would be necessary for the creation of the reservoir. When the storage of the reservoir exceeds approximately 400,000 acre-feet, saddle dams would be required.

As a joint EBMUD-CCWD project, Los Vaqueros would be filled with surplus Mokelumne water from the Sierra Nevada. If EBMUD has separate facilities, a 66-inch diameter pipeline would be needed to transport water into EBMUD's service area during an emergency outage. The pumping plant could be located at a number of sites, but should be located in

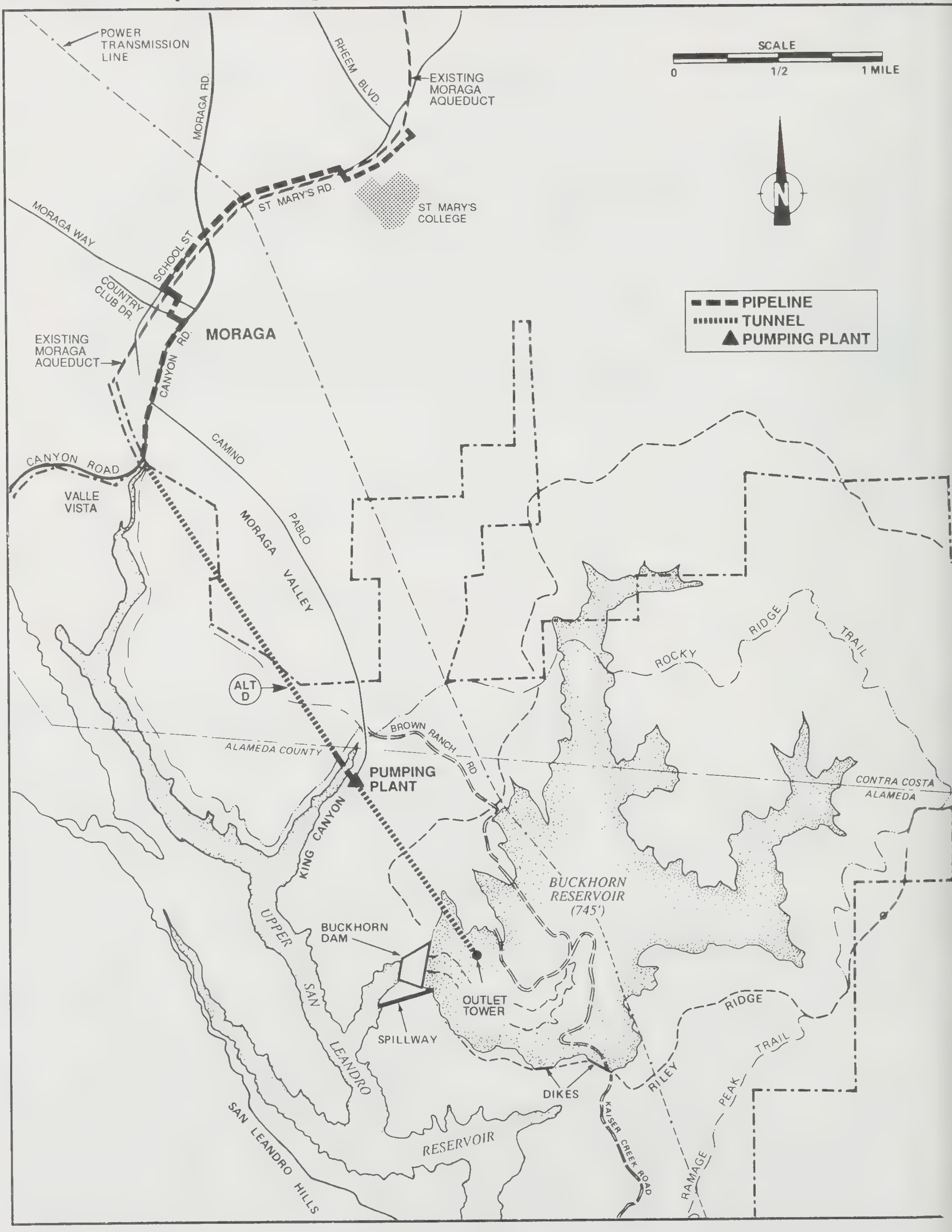
# Buckhorn Reservoir (745')
# Alternative Aqueduct Alignments

Figure VI-12



# Buckhorn Reservoir (745')
# Alternative Aqueduct Alignment

Figure VI-13



## Buckhorn Aqueduct Route Alternatives

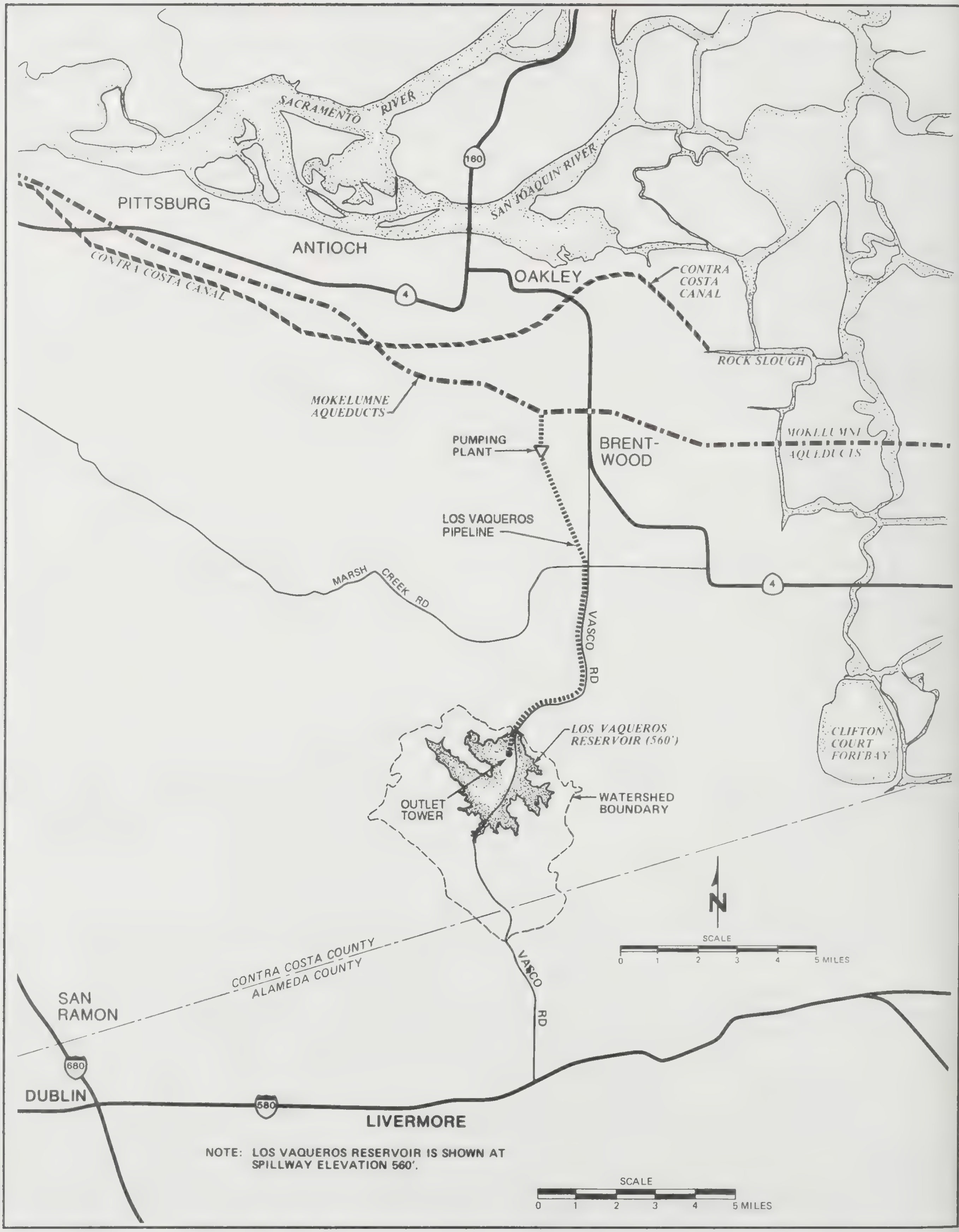
Figure VI-14

| ALTERNATIVE | COSTS | | | | | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|---|---|---|
| | AQUEDUCT ($M) | PUMPING PLANT ($M) | TOTAL CAPITAL ($M) | FILLING ($M) | O&M* ($M) | | |
| **AS PROPOSED IN DEIR**<br><br>New pipeline along St Mary's Road, School Street, Country Club Drive, St Mary's Road, Canyon Road, and Camino Pablo Road. New tunnel from Camino Pablo to outlet tower. Gravity flow back into the service area.<br><br>Pipeline: 23,000' (6' D)<br>Tunnel: 5,500' (7' D)<br>Buckhorn PP: 5,600 HP | 29 | 5 | 34 | 17 | 20 | • Low tunnel cost.<br>• Shortest pipeline.<br>• Pipeline and tunnel avoid slide prone areas. | • Short term construction impacts on local street, businesses, and residents. |
| **ALTERNATIVE A**<br><br>New pipeline from Buckhorn Pumping Plant to Stafford Drive. New tunnel from Stafford Drive to outlet tunnel. Discharge facility at King Canyon. Gravity flow back into the service area.<br><br>Pipeline: 3,500' (7' D)<br>Tunnel: 13,800' (7' D)<br>5,500' (7.5 D)<br>Buckhorn PP: 5,500 HP | 46 | 6 | 52 | 17 | 20 | • Less construction impacts on local streets, businesses and residents. | • High tunnel cost.<br>• First section of tunnel along St Mary's Road may require cut and cover. |
| **ALTERNATIVE B**<br><br>New pipeline along Bollinger Canyon Road. New tunnel/pipeline from Bollinger Canyon Road to outlet tower.<br>Gravity flow back into the service area.<br><br>Pipeline: 10,400' (8' D)<br>Tunnel: 9,600' (8' D)<br>5,500' (9' D)<br>Buckhorn PP: 5,300 HP | 42 | 5 | 47 | 17 | 20 | • Little impact on local businesses during construction. | • Requires complete closure of Bollinger Canyon Road for pipeline construction. |
| **ALTERNATIVE C**<br><br>New pipeline from St Mary's Road to Valle Vista. New tunnel from Valle Vista to outlet tower. Gravity flow back into the service area.<br><br>Pipeline: 14,200 (7' D)<br>Tunnel: 8,800' (7" D)<br>5,500' (7.5' D)<br>Buckhorn PP at St Mary's: 5,600 HP | 45 | 5 | 50 | 17 | 20 | • Avoids construction along Camino Pablo Road. | • Short term construction impacts on local street, businesses, and residents. |
| **ALTERNATIVE D**<br><br>New pipeline from Moraga Road to Valle Vista. New tunnel from Valle Vista to King Canyon. Gravity flow back into the service area.<br><br>Pipeline: 6,700 (8' D)<br>1,000' (9' D)<br>Tunnel: 8,800' (9' D)<br>5,500' (10' D)<br>Buckhorn PP at King Canyon: 5,700 HP | 41 | 6 | 47 | 18 | 21 | • Little impact on local streets, businesses, and residents. | • Short term construction impacts on local street, businesses, and residents. |

*Present Worth Cost. Includes engineering, administration and 10% contingencies.

# Los Vaqueros (560')
# Proposed Aqueduct Alignment

Figure VI-15



an area below 100 feet in elevation to provide adequate suction for the pumps. One option for the pumping plant is Fairview Avenue near Dainty Road. The reservoir would be filled from the Mokelumne Aqueducts at a point near Oakley through approximately 50,700 feet of 66-inch diameter pipeline to a 72-inch diameter tunnel into the reservoir. This is the preferred alignment. The pipeline could also connect with the CCWD's Contra Costa Canal, which is approximately 2.5 miles north of the Mokelumne Aqueducts. The tie-in point on the Contra Costa Canal would be just upstream of CCWD's Pumping Plant No. 4.

EBMUD would operate its portion of Los Vaqueros Reservoir similar to Buckhorn Reservoir. When excess supply from the Mokelumne Aqueduct is available, water would be pumped from the aqueduct to the reservoir. When water is needed from the reservoir, water would flow by gravity or be pumped through the pipeline into the Mokelumne Aqueducts. Figure VI-16 shows the hydraulic operations for Los Vaqueros Reservoir. CCWD would operate its portion of the reservoir differently, purchasing its supply of water from EBMUD or obtaining another source of water of equivalent quality.

While many pipeline alignments were evaluated, the most feasible alternatives are shown in Figure VI-17 and summarized in Figure VI-18.

Considerable geotechnical work has been done to evaluate potential dam sites for Los Vaqueros Reservoir. These include studies by the DWR, the USBR, and private consultants for CCWD. The most recent study, by Woodward-Clyde Consultants, was performed in 1987 and utilized the previous studies along with further field investigations. This study identified four potential dam sites along Kellogg Creek and concluded that the location proposed (See Figure V-15) would be the most feasible. The proposed location of the dam would minimize the construction cost because it would minimize the volume of the dam embankment.

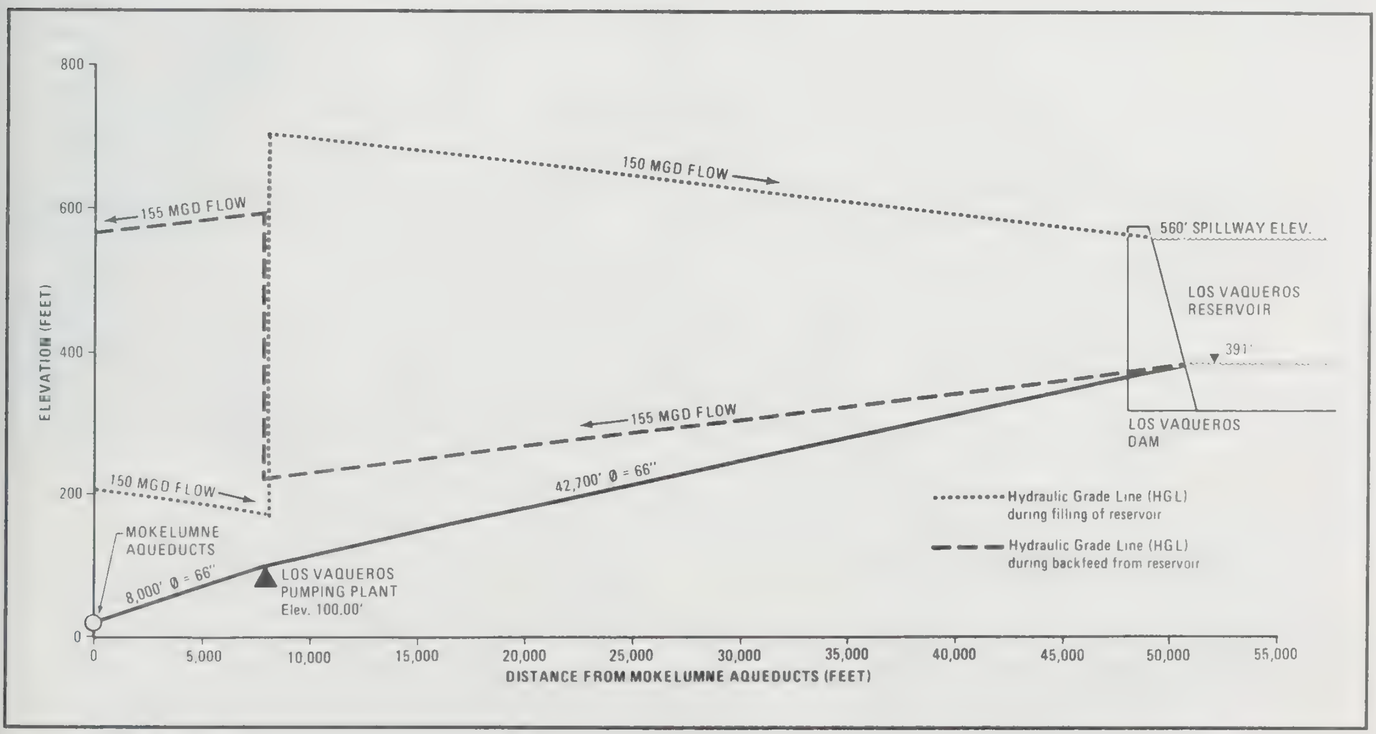
While Los Vaqueros Reservoir would meet all three EBMUD objectives, it is not located within the District's service area. This could present a problem because, if an aqueduct outage occurred between the reservoir and the service area, water from the reservoir could not be used. Because Los Vaqueros would be filled with Mokelumne water which is surplus to EBMUD's needs, the quantity of water EBMUD could provide to CCWD may be less than they desire.

## WATER QUALITY ANALYSIS OF TERMINAL RESERVOIR SITES

Chapter IV concluded that terminal reservoirs should be filled with only high quality Sierra sources to avoid water quality problems such as those experienced by

### Operation of Los Vaqueros Reservoir

Figure VI-16



## Los Vaqueros (560')
## Alternative Aqueduct Alignments

Figure VI-17

# Los Vaqueros Aqueduct Route Alternatives

Figure VI-18

| ALTERNATIVE | COSTS | | | | | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|---|---|---|
| | AQUEDUCT ($M) | PUMPING PLANT ($M) | TOTAL CAPITAL ($M) | FILLING ($M) | O&M* ($M) | | |
| **AS PROPOSED IN DEIR**<br>New pipeline along Empire Avenue to Vasco Road.<br>Pipeline: 50,700' (5.5' D)<br>Tunnel 3,800'<br>Pumping Plant: 25,200 HP | 38 | 15 | 40 | 13 | 27 | • Short pipeline length.<br>• Less disruption to homes and roads.<br>• Compatible with planned CCWD Los Vaqueros project.<br>• Avoids City of Brentwood. | • Some disruption to orchards. |
| **ALTERNATIVE A**<br>New pipeline along Fairview Ave, Balfour Road, Walnut Blvd and Vasco Road.<br>Pipeline: 56,700' (5.5' D)<br>Tunnel 3,800'<br>Pumping Plant: 26,100 HP | 41 | 16 | 44 | 14 | 28 | • Compatible with planned CCWD Los Vaqueros project<br>• Avoids City of Brentwood. | • Some disruption to homes and roads.<br>• May interfere with utilities along route making construction more difficult.<br>• Longer pipeline length. |
| **ALTERNATIVE B**<br>New pipeline along Southern Pacific RR, Walnut Blvd and Vasco Road.<br>Pipeline: 50,300' (5.5' D)<br>Tunnel 3,800'<br>Pumping Plant: 25,200 HP | 38 | 15 | 41 | 13 | 27 | • Compatible with planned CCWD Los Vaqueros project. | • Route passes through City of Brentwood making construction more difficult and causing more traffic problems. |
| **ALTERNATIVE C**<br>New pipeline along Seller Road, Marsh Creek Road and Vasco Road.<br>Pipeline: 51,800' (5.5' D)<br>Tunnel 3,800'<br>Pumping Plant: 25,400 HP | 39 | 15 | 42 | 13 | 27 | • Avoids City of Brentwood. | • Not compatible with planned CCWD Los Vaqueros project. |
| **ALTERNATIVE D**<br>New pipeline from Mokelumne Aqueducts to Vasco Road then along Vasco Road.<br>Pipeline: 47,000' (5.5' D)<br>Tunnel 3,800'<br>Pumping Plant: 24,700 HP | 37 | 15 | 39 | 13 | 26 | • Shortest pipeline length.<br>• Avoids City of Brentwood. | • Not compatible with planned CCWD Los Vaqueros project.<br>• Some disruption to orchards. |

*Present Worth Cost. Includes engineering, administration and 10% contingencies.

EBMUD with the use of Delta water during the 1976-77 drought. These water quality concerns include excessive salinity, high THM formation potential, taste and odors, and incompatibility with the District's water treatment system.

Terminal reservoir watersheds should also be protected from urban development to prevent pollution caused by urban runoff which leads to toxic and carcinogenic chemical contamination, sewage contamination, taste and odors, siltation, and increased treatment costs. A fully protected watershed would allow less costly direct filtration treatment to be applied to the water.

Terminal reservoirs should also be as deep as possible to allow the selection of water at depths below taste and odor causing algal growths near the surface yet above the higher turbidities and anoxic taste and odors near the bottom.

A water quality evaluation of the alternative terminal reservoir site is summarized in Figure V-19.

### Buckhorn Reservoir

From a water quality perspective, Buckhorn is the best terminal reservoir site because it (1) would be filled directly with high quality Mokelumne water, (2) would have a relatively small, undeveloped watershed (6.5 square miles), (3) would be able to be treated at EBMUD's direct filtration plants and (4) would be the deepest (200 to 265 feet at the outlet tower) of the potential reservoirs. The quality of the reservoir would be expected to be similar to that of EBMUD's existing high quality Briones Reservoir (see Figure IV-3).

### Pinole Reservoir

Pinole Reservoir would be filled with San Pablo Reservoir water and runoff from 11.4 square miles watershed on which significant agricultural development has occurred. San Pablo Reservoir is filled with Mokelumne water and runoff from a 26 square mile watershed which includes the City of Orinda. Agricultural activities on the Pinole watershed include tomato and hay farming, cattle grazing and horse pasturage. Pinole Reservoir would also be relatively shallow (62 to 89 feet at the outlet tower), about the same depth as San Pablo and Upper San Leandro Reservoirs.

Because of the runoff from urban areas that enter it, and the fact that it is shallow, San Pablo Reservoir is currently subject to persistent taste and odors in the summertime. Since it would be shallow and filled from San Pablo Reservoir and possible agricultural runoff, Pinole Reservoir would also be expected to be subject to persistent taste and odors in the summertime. The quality of the reservoir would be expected to be similar to that of San Pablo Reservoir (see Figure IV-3) and would be treated at Sobrante Filter Plant, a full treatment plant.

### Los Vaqueros Reservoir

Los Vaqueros Reservoir could be filled with either Delta water or Sierra sources or both. Its 19 square mile watershed is undeveloped except for cattle grazing. The reservoir would be considerably deeper than Pinole Reservoir but shallower than Buckhorn Reservoir.

## Water Quality Evaluation of Terminal Reservoir Sites

Figure VI-19

| ALTERNATIVE | IMPORTED SOURCE WATER | TYPE OF DEVELOPMENT ON WATERSHED | SIZE OF WATERSHED (square miles) | DEPTH OF RESERVOIR AT OUTLET TOWER (feet) | TREATMENT REQUIREMENTS | ANTICIPATED WATER QUALITY PROBLEMS |
|---|---|---|---|---|---|---|
| BUCKHORN | Direct Mokelumne | None | 6.5 | 200 to 265 | Direct filtration | None |
| PINOLE | San Pablo Reservoir | Pinole — Agriculture<br>San Pablo — Urban | 11<br>26 | 62 to 89 | Full treatment | Taste and odor |
| LOS VAQUEROS | Delta/Sierra water blend | None | 19 | 190 | Full treatment (not compatible with EBMUD treatment facilities) | Taste and odor<br>THMs |
| | Sierra water | None | 19 | 190 | Direct filtration | None |

If any Delta water is used to fill Los Vaqueros Reservoir, the California Department of Health Services would likely require full treatment of the water which is not compatible with EBMUD's direct filtration plants. Based on past experience with Delta water in San Pablo and Upper San Leandro Reservoirs, problems with taste and odors and high THM levels would likely occur.

If Sierra water sources only are used to fill the reservoir then the water would be treatable at EBMUD's direct filtration plants as long as the turbidity in the reservoir due to local runoff from the larger watershed is not excessive.

## SITE SELECTION

The storage needed for both security and shortage is 145,000 acre-feet.

Of the three best alternatives, Pinole, Buckhorn, and Los Vaqueros, only two provide adequate storage to meet the security and supply objectives. They are Buckhorn and Los Vaqueros.

| Site Options | Usable Storage | Capital Costs* |
|---|---|---|
| Buckhorn (745') | 143,000 acre-feet | $152M |
| Los Vaqueros (560') | 144,000 acre-feet (EBMUD only) | $186M |

*Costs in 1988 dollars & do not include initial filling of reservoir

Los Vaqueros would in all likelihood be a joint project with CCWD and other agencies. EBMUD would participate in such a joint project only if the reservoir would be filled with Sierra water. Because of the urgency to address EBMUD's near-term water supply issues and the complexities associated with a joint Los Vaqueros Project with CCWD, Buckhorn Reservoir should be given further consideration.

Buckhorn Reservoir would be located within the District's service area. It would be a deep reservoir in a remote area with a protected watershed. This would make it easier to control activities on the watershed and taste and odor problems in the reservoir.

Buckhorn Reservoir with a total storage capacity of 145,000 acre-feet is the recommended site if additional terminal storage is constructed.

# Appendix A
# Notice of Preparation

**(Available for Review at EBMUD District Office)**

# Appendix B
# EIR Authors, Organizations and Individuals Consulted

## EIR AUTHORS

### LEAD AGENCY

East Bay Municipal Utility District
Water Resources Planning Division
P.O. Box 24055
Oakland, California 94623

Anne Matsushino, Project Manager

### CONSULTANTS

EIP Associates
150 Spear Street, Suite 1500
San Francisco, California 94105

| | |
|---|---|
| Project Manager | — John Davis |
| Deputy Project Manager | — John Kennedy |
| Land Use | — Jennifer Toth and Mustafa Jenneh |
| Hydrology | — David Friedland |
| Geology and Soils | — George Burwasser and Roger Papler |
| Vegetation and Wildlife | — Ric Villasenor |
| Traffic | — Rick Dowling |
| Noise | — John Kennedy |
| Air Quality | — David Friedland |
| Cultural Resources | — Allan Pastron |
| Visual Quality | — Jennifer Toth |
| Public Health and Safety | — John Kennedy |

## ORGANIZATIONS AND INDIVIDUALS CONSULTED

| | |
|---|---|
| California Department of Fish and Game | — Sylvia Gude<br>— Frank Hall<br>— F. Grey<br>— R. Holland<br>— John Imig |
| U.S. Fish and Wildlife Service | — Louise Accurso<br>— Leigh Robinson |
| East Bay Regional Parks District | — Peter Alexander<br>— Tom Lindenmeyer<br>— Keven Shea |
| University of California, Museum ofVertebrate Zoology | — Dr. William Lidicker |
| California Office of Planning and Research | — Norma Wood |
| California State University Hayward, Dept. of Biological Sciences | — Rolf W. Bensler |
| California Academy of Sciences | — W. Knight |
| Aleutian Canada Geese Recovery Team | — P. Springer |
| Mulberry Tree School | — Mary Ann McCloud |
| Joaquin Moraga Intermediate School | — Susan Harrison |
| Camino Pablo Elementary School | — Rita Fox |
| Moraga Public Library, Front Desk | |
| Saint Mary's College, Admissions Office | |
| U.S. Soil Conservation Service | — Bill Brunner |
| California Division of Mines and Geology | — Rob Hauser |
| U.S. Geological Survey | |
| Bay Area Air Quality Management District | — Milton Feldstein |
| EBMUD: Watershed and Recreation Division | — R. C. Nuzum<br>— S. Abbors<br>— Rod Tripp |
| U.S. Army Corps of Engineers | — Sharon Moreland |

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# Appendix DI

# List of Plants and Animals

| Common Name | Scientific Name | Habitat |
|---|---|---|
| Bobcat | Lynx rutus | R,W,G,S,C |
| Coyote | Canus lafrens | R,W,G,S,C |
| Hoofed Animals | | |
| Black-tailed deer* | Odocoileus hemionus | W,R,G,S,C |
| BIRDS | | |
| Common loon | Gavia immer | A |
| Pied-billed grebe | Podilymbus podiceps | A |
| Western grebe | Aechmophorus occidentalis | A |
| Great egret* | Casmerodius albus | A |
| Snowy egret | Egretta thula | A |
| Great blue heron* | Ardea herodius | A |
| Green-backed heron | Butorides striatus | A,R |
| Snow goose | Chen c. caerulescens | A |
| Ross' goose | Chen rossii | A |
| Canada goose | Branta canadensis | A |
| Aleutian Canada goose | branta canadensis leucopareia | A |
| White-fronted goose | Anser albirrons | A |
| Mallard* | Anas platyrhynchos | A |
| Wood duck | Aix sponsa | A,R |
| Common merganser | Mergus merganser | A |
| Turkey vulture* | Cathartes aura | R,G,W,S,C |
| Black-shouldered kite | Elanus caeruleus | R,G |
| Sharp-shinned hawk | Accipiter striatus | R,W |
| Cooper's hawk | Accipiter cooperii | R,W,S,C |
| Swainson's hawk | Buteo swainsoni | R,G |
| Red-tailed hawk* | Buteo jamaicensis | R,G,W |
| Northern Harrier | Circus cyaneus | R,G |
| Golden eagle* | Aguila chrsaetos | R,G,W |
| Osprey | Pandion haliaetus | A,R |
| American kestral | Falco sparverius | G,W,S,C |
| California quail* | Lophortyx californicus | G,W,S,C |
| American coot | Fulica americana | A |
| Killdeer* | Charadrius vociferus | G |
| Band-tailed pigeon | Columba fasciata | R,W |
| Rock dove* | Columbau livia | G,W |
| Mourning dove* | Zenaida macroura | R,W,S,C |
| Barn owl | Tyto alba | G,R,W |
| Screech owl | Otus asio | W |
| Great horned owl | Bubo virgianus | R,W |
| Anna's hummingbird | Calypte anna | R,W,S,C |
| Rufous hummingbird | Salasphorus rufus | R,W,S,C |
| Allen's hummingbird | Salasphorus sasin | R,W,S,C |
| Calliope hummingbird | Stellula calliope | R |
| Belted kingfisher | Megaceryle alcyon | A,R |
| Orange-crowned Warbler | Vermirora celata | R,W |
| Lazuli Bunting | Passerina amoena | R,W |

| Common Name | Scientific Name | Habitat |
|---|---|---|
| Horned lark | Eremophila apestris | G |
| Rufus-crowned sparrow | Aimophila ruficeps | G |
| Grasshopper sparrow | Ammodramus savannarum | G |
| Northern flicker* | Colaptes auratus | R,W |
| Yellow-bellied sapsucker* | Sphyrapicus varius | R,W |
| Hairy woodpecker | Picoides villosus | R,W |
| Downy woodpecker | Picoides pubescens | R,W |
| Nuttall's woodpecker | Picoides nuttallii | R,W |
| Acorn woodpecker | Melanerpes formicivorus | R,W |
| Ashthroated flycatcher* | Myiarchus cinerascens | R,W |
| Black phoebe | Sayornis nigricans | R,W |
| Say's phoebe | Sayornis saya | G,R,W,S,C |
| Western flycatcher* | Empidonax difficilis | R,W |
| Olive-sided flycatcher | Nuttallornis borealis | R |
| Western kingbird | Tyrannus verticalis | G,R,W |
| Violet-green swallow | Tachycineta thalassina | G,W |
| Rough-winged swallow | Stelgidopteryx ruficollis | G,W |
| Barn swallow* | Hirundo rustica | G,W |
| Bank swallow | Riparia riparia | A,R |
| Cliff swallow | Petrochelidon pyrrhonota | A,G,W,R |
| Tree swallow | Tridoprocne bicolor | R,W |
| Steller's jay* | Cyanocitta stelleri | R,W,S,C |
| Scrub jay* | Aphelocoma coerulescens | R,W,S,C |
| Common crow* | Corvus brachyrhynchos | R,W,S,C |
| Chestnut-backed chickadee* | Parus rufescens | R |
| Plain titmouse* | Parus inornatus | R,W |
| Bushtit* | Psaltiparuss minimus | R,S,C |
| Red-breasted nuthatch | Sitta canadensis | R |
| White-breasted nuthatch | Sitta carolinensis | R |
| Brown creeper | Certhia familiaris | R |
| Wrentit | Chamaea fasciata | S,C |
| Dipper | Cinclus mexicanus | R |
| Winter wren | Troglodytes troglodytes | R |
| Bewick's wren* | Thryomanes bewickii | S,C |
| Mockingbird* | Mimus polyglottos | R,W,S,C |
| California thrasher | Toxostoma redivivum | S,C |
| American robin | Turcus migratorius | R,W,S,C |
| Varied thrush | Ixoreus naevius | W |
| Hermit thrust | Catharus guttatus | R,S,C |
| Swainson's thrush | Catharus ustulatus | R |
| Western bluebird* | Sialia mexicana | W,S,C |
| Golden-crowned kinglet | Regulus satrapa | W,R |
| Ruby-crowned kinglet | Regulus calendula | W,R |
| Starling* | Sturnus vulgaris | G,R |
| Solitary vireo | Vireo solitarius | R,W |
| Warbling vireo | Vireo gilvus | R,W |
| Yellow warbler* | Dendroica petechia | R,W |
| Yellow-rumped warbler | Dendroica coronata | R,W |
| Townsend's warbler | Dendroica townsendi | R,W |

| Common Name | Scientific Name | Habitat |
| --- | --- | --- |
| Wilson's warbler | Wilsonia pusilla | R,W,S,C |
| House sparrow | Passer domesticus | G,S,C |
| Western meadowlark* | Sturnella neglecta | G |
| Red-winged blackbird* | Aagelaius phoeniceus | G,R |
| Brewer's blackbird | Euphagus cyanocephalus | G,R |
| Bullock's oriole | Icterus galbula bullockii | R,W |
| Dark-eyed junco* | Junco hyemalis | R,W |
| Purple finch* | Carpodacus purpureus | R,W |
| House finch* | Carpodacus mexicanus | G,R,W |
| American goldfinch* | Carduelis tristis | G,R |
| Lesser goldfinch* | Carduelis psaltria | R,W,S,C |
| Rufous-sided towhee* | Pipilo erythropthalmus | R,S,C |
| Brown towhee* | Pipilo fuscus | R,S,C |
| Savannah sparrow | Passerculus sandwichensis | G |
| White-crowned sparrow | Zonotrichia leucophrys | S,C |
| Golden-crowned sparrow | Zonotrichia atricapilla | S,C |
| Fox sparrow | Passerella iliaca | S,C |
| Lincoln's sparrow | Melospiza lincolnii | R,W |
| Song sparrow | Melospiza melodia | G,R,S,C |

AMPHIBIANS

| | | |
| --- | --- | --- |
| Rough-skinned newt | Taricha granulose | A,R,W |
| California newt* | Taricha toriosa | A,R,W |
| Arboreal salamander | Aneides lugubris | R,W |
| California slender salamander | Batrachoseps attenuatus | R,W |
| Ensatina | Ensatina eschscholtzii | R,W |
| Red-legged frog | Rana aurora | A,R |
| Bullfrog* | Rana catesbeiana | A,R |
| Pacific treefrog | Hyla regilla | A,R |

REPTILES

| | | |
| --- | --- | --- |
| Western pond turtle* | Clemmys marmorata | A,R |
| Western fence lizard* | Sceloperus occidentalis | R,W,S,C |
| Northern alligator lizard* | Gerrhonotus coeruleus | G,R,W,S,C |
| Southern alligator lizard | Gerrhonotus multicarinatus | G,R,W,S,C |
| Western skink | Eumeces skiltonianus | W,R,S,C |
| Ringneck snake | Diadophis punctatus | R |
| Common kingsnake | Lampropeltis getulus | G,S,C |
| Alameda striped racer | Masticophis lateralis euryxanthus | R,S,C |
| Gopher snake | Pituophis melanoleucus | G,S,C |
| Western aquatic garter snake | Thamnophis couchi | A,R |
| Western terrestrial garter snake | Thamnophis elegans | A,R |
| Common garter snake | Thamnophis sirtalis | A,R |

| Common Name | Scientific Name | Habitat |
|---|---|---|
| Coast horned lizard | Rhrynosoma coronatum | |
| Rubber boa | Charina bottae | |
| Sharp-tailed snake | Hypsiglena torquata | |
| Western rattlesnake | Cortalus viridis | |

KEY

A = Aquatic G = Grassland R = Riparian S = Scrub C = Chapparral W = Woodland

## PLANT LIST

| COMMON NAME | SCIENTIFIC NAME |
|---|---|
| Alder | Alnus rhombifolia |
| Arroyo Willow | Salix lasiolepis |
| Beard-Grass | Polypogon monspeliensis |
| Bedstraw | Galium sp. |
| Bellardia | Bellardia trixago |
| Big-Leaf Maple | Acer macrophyllum |
| Bird's-foot Trefoil | Lotus corniculatus |
| Bitter Cherry | Prunus emarginata |
| Black Medick | Medicago lupulina |
| Black Oak | Quercus kelloggii |
| Blackberry | Rubus sp. |
| Blow-Wives | Achyrachaena mollis |
| Blue Dicks | Dichlostemma puchellum |
| Blue Gum | Eucalyptus globulus |
| Blue-Eyed Grass | Sisyrinchium bellum |
| Bracken Fern | Pteridium aquilinum |
| Brittleleaf Manzanita | Arctostaphylos tomentosa ssp. crustacea |
| Bur Clover | Medicago polymorpha |
| Bur-Chervil | Anthriscus neglecta |
| California Bay | Umbellularia california |
| California Buckeye | Aesculus californica |
| California Canary-Grass | Phalaris californica |
| California Coffeeberry | Rhamnus californica |
| California Figwort | Scrophularia californica |
| California Fuchsia | Epilobium canum |
| California Gooseberry | Ribes californicum |
| California Hazelnut | Corylus cornuta ssp. californica |
| California Hop-Tree | Ptelea crenulata |
| California Pipevine | Aristolochia californica |
| California Polypody | Polypodium californicum |
| California Poppy | Eschscholzia californica |
| California Sage | Artemisia californica |
| California Tea | Psoralea physodes |
| Cat's Ear | Hypochaeris glabra |
| Cat-Tail | Typha latifolia |
| Cat-Tail | Typha sp. |
| Chamise | Adensostoma fasciculatum |
| Chase's Oak | Quercus X chasei |
| Checker | Sidalcea malvaeflora |
| Clover | Trifolium barbigerum |
| Clover | Trifolium tridentatum ssp. aciculare |
| Clover | Trifolium sp. |
| Coast Live Oak | Quercus agrifolia |
| Columbine | Aquilegia formosa |
| Common Barley | Hordeum vulgare |
| Cottonwood | Populus trichocarpa |
| Cow-Parsnip | Heracleum lanatum |
| Coyote Brush | Baccharis pilularis ssp. consanquinea |

| COMMON NAME | SCIENTIFIC NAME |
|---|---|
| Coyote-Mint | Monardella sp. |
| Cream Bush | Holodiscus discolor |
| Cream Cups | Platystemon californicus |
| Current | Ribes divaricatum var. pubiflorum |
| Dense-flowered Lupine | Lupinus densiflorus ssp. aurea |
| Elderberry | Sambucus mexicana |
| Eriogonum | Eriogonum sp. |
| Evax | Evax sparsiflora |
| Fairy Bells | Disporum sp. |
| False Solomon's-Seal | Smilacina stellata var. sessilifolia |
| Fiddleneck | Amsinckia menziesii |
| Field Madder | Sherardia arvensis |
| Filaree | Erodium cicutarium |
| Four-spotted Godetia | Clarkia purpurea var. quadrivulnera |
| Foxtail | Hordeum sp. |
| Geranium | Geranium molle |
| Geranium | Geranium disectum |
| Gilia | Gilia achilleaefolia |
| Gold Backed Fern | Pityrograma triangularis |
| Gray Mule Ears | Wyethia helenioides |
| Hair-grass | Aira caryophyllea |
| Hedge-Nettle | Stachys ajugoides |
| Hedge-Nettle | Stachys rigida var. quercetorum |
| Hemp | Cannabis sativa |
| Hind's Walnut | Juglans hindsii |
| Hound's Tongue | Cynoglossum grande |
| Indian Paint-Brush | Castilleja foliolosa |
| Italian Thistle | Carduus pycnocephalia |
| Ithuriel's Spear | Triteleia laxa |
| Johnny Jump-up | Viola pedunculata |
| Lindley's Lupine | Lupinus bicolor |
| Little Quaking-Grass | Briza minor |
| Madrone | Arbutus menziesii |
| Meadow barley | Hordeum brachyantherum |
| meadow-Rue | Thalictrum polycarpum |
| Microseris | Microseris sp. |
| Milk Thistle | Silybum marianum |
| Miner's Lettuce | Claytonia perfoliata |
| Mint | Mentha sp. |
| Morning Glory | Convolvulus sp. |
| Mouse-ear Chickweed | Cerastium sp. |
| Mugwort | Artemisia douglasiana |
| Mustard | Brassica sp. |
| Narrow-leaf Mule Ears | Wyethia angustifolia |
| Narrow-Leaf Plantain | Plantago lanceolata |
| Needle-Grass | Stipa sp. |
| Needle-Grass | Stipa pulchra |
| Needle-Grass | Stipa sp. |
| Nemophila | Nemophila parviflorum |
| Nightshade | Solanum sp. |

| COMMON NAME | SCIENTIFIC NAME |
|---|---|
| Nightshade | Solanum umbelliferum |
| Nut-Sedge | Cyperus sp. |
| Oso Berry | Osmaronia cerasiformis |
| Owl's Clover | Orthocarpus lithospermoides |
| Owl's Clover | Orthocarpus sp. |
| Pea | Lathyrus sp. |
| Peppergrass | Lepidium latipes |
| Peppergrass | Lepidium nitidium |
| Periwinkle | Vinca major |
| Phacelia | Phacelia sp. |
| Pineapple Weed | Matricaria matricoides |
| Pogogyne | Pogogyne serphylloides |
| Poison Hemlock | Conium maculatum |
| Popcorn Flower | Plagiobothrys trachycarpus |
| Popcorn Flower | Plagiobothrys nothofulvus |
| Prickly Ox-Tongue | Picris echioides |
| Rat-tail Fescue | Vulpia myuros |
| Red Brome | Bromus rubens |
| Red Maids | Calandrinia ciliata var. menziesii |
| Red Willow | Salix laevigata |
| Ripgut-Grass | Bromus diandrus |
| Rush | Juncus sp. |
| Sanicle | Sanicula bipinnatifida |
| Scarlet Pimpernel | Anagalis arvensis |
| Scouring Rush | Equisetum sp. |
| Sedge | Carex sp. |
| Service-berry | Amelanchier alnifolia |
| Shepard's Needle | Scandix pecten-veneris |
| Shepard's Purse | Capsella bursa-pastoris |
| Smooth Brome | Bromus inermis |
| Snowberry | Symphoricarpos sp. |
| Soap-Plant | Chlorogalum pomeridianum |
| Soft Chess | Bromus mollis |
| Sorrel | Rumex acetosella |
| Spotted Medick | Medicago arabica |
| Steam Dogwood | Cornus stolonifera |
| Sitkcy Monkey-Flower | Mimulus aurantiacus |
| Stinging Nettle | Urtica holosericea |
| Strawberry | Fragaria sp. |
| Succulent Annual Lupine | Lupinus succulentus |
| Summer Lupine | Lupinus formosus |
| Sun Cups | Camissonia ovata |
| Sweet-Cicely | Osmorhiza chilensis |
| Thistle | Cirsium sp. |
| Tree Lupine | Lupinus albifrons |
| Trillium | Tirllium chloropetalum |
| Valley Oak | Quercus lobata |
| Verbena | Verbena sp. |
| Vetch | Vicia sativa |
| Vine Maple | Acer negundo |

| COMMON NAME | SCIENTIFIC NAME |
|---|---|
| Wall Barley | Hordeum murinum |
| Water-Cress | Nasturtium officinale |
| White-Top | Cardaria draba |
| Wild Cucumber | Marah fabaceus |
| Wild Oats | Avena sp. |
| Wild Raddish | Raphanus sativus |
| Wood Rush | Luzula sp. |
| Woodland Star | Lithophragma sp. |
| Yarrow | Achillea millefolium |
| Yellow Sweet-Clover | Melilotus indica |
| Zigadene | Zigadenus sp. |

## PLANT LIST
KAISER/BUCKHORN CREEK SITE

### GRASSLAND

HERBACEOUS DICOTS

Amsinckia intermedia
Amsinckia menziesii
Anagalus arvensis
Brassica sp.
Calandrinia ciliata menziesii
Camissonia ovata
Capsella bursa-pastoris
Cerastium sp.
Dichlostemma puchellum
Erodium cicutarium
Eschscholzia californica
Gilia achilleaefolia
Lepidium nitidum
Lupinus bicolor
Lupinus formosus
Matricaria matricoides
Medicago arabica
Medicago lupulina
Melilotus indica
Orthocarpus sp.
Plagiobothrys nothofulvus
Plantago lanceolata
Platystemon californicus
Ranunculus californica
Rumex acetosella
Sanicula bipinnatifida
Sherardia arvensis
Sidalcea malvaeflora
Sisyrinchium bellum
Raphanus sativus
Trifolium sp.
Triteleia laxa
Viola pedunculata
Wyethia helenioides

GRASSES

Avena sp.
Briza minor
Bromus diandrus
Bromus mollis
Bromus rubens
Hordeum murinum
Hordeum sp.
Lolium multiflorum
Stipa sp.
Vulpia myuros

TREES

Quercus lobata

### SCRUB

DOMINANTS

Artemisia californica
Baccharis pilularis consanguinea
Lupinus albifrons
Mimulus aurantiacus
Rhamnus californica
Toxicodendron diversilobum

OTHERS

Artemisia douglasiana
Castilleja foliolosa
Chlorogalum pomeridianum
Epilobium canum
Eriogonum sp.
Marah fabaceus
Monardella sp.
Phacelia sp.
Pogogyne serphylloides
Potentilla glandulosa
Psoralea physodes
Pteridium aquilinum
Ribes californicum
Rubus sp.
Stipa pulchra
Vicia sp.
Wyethia helenioides
Zigadenus sp.

## OAK WOODLAND & MIXED EVERGREEN FOREST

DOMINANTS

Acer macrophyllum
Aesculus californica
Arbutus menziesii
Quercus agrifolia
Umbellularia californica

UNDERSTORY

Anthriscus neglecta
Aquilegia formosa
Carex sp.
Claytonia perfoliata
Cynoglossum grande
Disporum sp.
Galium sp.
Geranium molle
Geranium disectum
Lathyrus sp.
Lithophragma sp.
Luzula sp.
marah fabaceus
Nemophila parviflorum
Osmaronia cerasiformis
Osmorhiza chilensis
Pityrograma triangularis
Polypodium californicum
Psoralea physodes

Pteridium aquilinum
Quercus X chasei
Ribes californicum
Ribes divaricatum pubiflorum
Smilacina stellata sessilifolia
Stachys rigida quercetorum
Symphoricarpus sp.
Toxicodendron diversilobum
Trillium chloropetalum angustipetalum
Vicia sp.
Wyethia helenioides

## RIPARIAN

### DOMINANTS

Acer macrophyllum
Acer negundo californicum
Alnus rhombifolia
Populus trichocarpa
Quercus agrifolia
Salix laevigata
Salix lasiolepis
Umbellularia californica

### UNDERSTORY

Carex sp.
Claytonia perfoliata
Conium maculatum
Disporum sp.
Equisetum sp.
Fragaria sp.
Geranium molle
Heracleum lanatum
Juncus sp.
Juglans sp.
Marah fabaceus
Nasturtium officinale
Osmaronia cerasiformis
Psoralea physodes
Pteridium aquilinum
Ribes divaricatum
Rubus sp.
Sambucus sp.
Scrophularia californica
Smilacina stellata sessilifolia
Solanum umbelliferum
Solanum sp.

Stachys rigida quercetorum
Symphoriarpus sp.
Thalictrum polycarpum
Toxicodendron diversilobum
Trillium chloripetalum angustipetalum
Urtica holosericea

## CHAPARRAL

Adenostoma fasciculatum
Amelanchier alnifolia
Arctostaphylos sp.
Castilleja foliolosa
Prunus emarginata
Quercus sp.
Zigadenus sp.

PINOLE CREEK SITE

## GRASSLAND

### GRASSES

Aira caryophyllea
Avena sp.
Briza minor
Bromus diandrus
Bromus inermis
Bromus mollis
Bromus rubens
Hordeum brachyantherum
Hordeum murinum
Hordeum vulgare
Hordeum sp.
Lolium multiflorum
Phalaris californica
Stipa sp.
Vulpia myuros

### TREES

Quercus lobata

### HERBACEOUS DICOTS

Achillea millefolium
Achyrachaena mollis
Amsinckia intermedia
Anagalus arvensis
Aristolochia californica
Bellardia trixago
Brassica sp.
Capsella bursa-pastoris
Cardaria draba
Carduus phenocephala
Carex sp.
Cerastium sp.
Clarkia purpurea quadrivulnera
Convolvulus sp.
Dichlostemma puchellum
Erodium cicutarium
Eschscholzia californica
Evax sparsiflora
Hypochaeris sp.
Lathyrus sp.
Lepidium latipes
Lepidium nitidum
Lotus corniculatus
Lupinus bicolor

Lupinus densiflorus aurea
Lupinus succulentus
Juncus sp.
Madia gracilis
Matricaria matricoides
Medicago lupulina
Medicago polymorpha
Melilotus indica
Microseris sp.
Orthocarpus lithospermoides
Plagiobothrys trachycarpus
Plantago lanceolata
Ranunculus californica
Rumex acetosella ?
Scandix pecten-vereris
Silybum marianum
Sisyrinchium bellum
Stachys ajugoides
Trifolium barbigerum
Trifolium tridentatum aciculare
Trifolium sp.
Triteleia laxa
Vicia sativa
Viola pedunculata
Whethia angustifolia
Wyethia helenioides

## SCRUB

DOMINANTS

Artemisia californica
Baccharis pilularis consanguinea
Toxicondendron diversilobum

OTHERS

Artemisia douglasiana
Eriogonum sp.
Marah fabaceus
Potentilla glandulosa
Pteridium aquilinum
Rubus sp.
Stipa pulchra

## OAK WOODLAND & MIXED EVERGREEN FOREST

DOMINANTS

Aesculus californica
Quercus agrifolia
Quercus kelloggii
Quercus lobata
Umbellularia californica

UNDERSTORY

Anthriscus neglecta
Carex sp.
Claytonia perfoliata
Corylus cornuta californica
Cynoglossum grande
Galium sp.
Geranium molle
Geranium disectum
Holodiscus discolor
Lathyrus sp.
Marah fabaceus
Nemophila parviflorum
Osmaronia cerasiformis
Osmorhiza chilensis
Pityrograma triangularis
Polypodium californicum
Potentilla glandulosa
Psoralea physodes
Ptelea crenulata
Pteridium aquilinum
Ribes Californicum
Ribes divaricatum pubiflorum
Rubus sp.
Smilacina stellata sessilifolia
Stachys rigida quercetorum
Symphoricarpus albus
Toxicondendron diversilobum
Wyethia helenioides

## RIPARIAN

DOMINANTS

Aesculus californica
Cornus stolonifera (C. californica)
Eucalyptus globulus
Juglans hindsii
Quercus agrifolia

Salix laevigata
Salix lasiolepis
Umbellularia californica

UNDERSTORY

Bromus sp.
Carduus pycnocephala
Carex sp.
Claytonia perfoliata
Conium maculatum
Equisetum sp.
Fragaria sp.
Geranium molle
Heracleum lanatum
Juncus sp.
Marah fabaceus
Medicago sp.
Mentha sp.
Nasturtium officinale
Osmaronia cerasiformis
Psoralea physodes
Pteridium aquilinum
Ribes divaricatum
Rosa sp.
Rubus sp.
Sambucus mexicana
Solanum sp.
Symphoriarpus sp.
Toxicodendron diversilobum
Urtica holosericea

# Appendix DII

# Historical Overview

# Historical Overview of the Proposed Buckhorn Reservoir Site
Alameda and Contra Costa Counties, California

Submitted to:

EIP Associates
319 Eleventh Street
San Francisco, California 94103

Submitted by:

Archeo-Tec
114 Wilding Lane
Oakland, California 94618
24 August, 1987

Site Location and Description

At the request of Mr. John Davis of EIP Associates in San Francisco, Allen G. Pastron, Ph.D, of Archeo-Tec has conducted an archival survey of the history of the proposed Buckhorn Reservoir site in Alameda and Contra Costa counties, California. The principal goals of the present report are to provide a general overview of the history of the project site and to describe the uses to which the property has been put from prehistoric times through the twentieth century. In order to develop the proposed Buckhorn Reservoir, the project sponsor, the East Bay Municipal Utility District (EBMUD), proposes to construct a dam and associated facilities and inundate an area of approximately 1601 acres.

The subject property is basically characterized by gently rolling grasslands, ranging in elevation between 460 and 840 feet above mean sea level. Dominant vegetation consists primarily of introduced, low-lying grasses including bunch grasses, brome grass, needle grass and a variety of forbs including cobweb thistle, cardoon thistle, lupine, Brodiaea, California Poppy, wild radish and mustard. Stands of Coast live oak and buckeye occur locally.

Riparian and sub-riparian conditions occur along permanent and semi-permanent drainages. The principal drainages within the project area are Buckhorn Creek, which courses in a southerly

direction, and Kaiser Creek, which courses southwesterly. Both of these drainages are lined, indeed choked, with riparian vegetation in the form of Coast live oak, Alder, California bay laurel, willow, maple, buckeye, sweet fennel, dock, berry thickets and poison oak; localized stands of bull rush, other rushes, cattails, and sedges were noted, especially near the center of the project area where the canyons open up and Buckhorn and Kaiser creeks come together. Finally, stands of imported eucalyptus were observed scattered throughout the proposed Buckhorn Reservoir site.

Dominant site geology consists primarily of soft, weathered sandstone which outcrops only rarely throughout the project area. Light brown, sandy soils predominate throughout the subject property. These soils are overlain by a layer of dark brown sandy topsoil of approximately 15 centimeters in depth throughout much of the project site. Numerous solifluction slumps resulting from meandering springs were observed throughout much of the proposed Buckhorn Reservoir project area.

Present usage of the proposed Buckhorn Reservoir is primarily devoted to cattle grazing. Alteration to the natural landscape has been extremely minimal: a series of dirt roads crisscross the project area. In addition, a single barn with attendant corrals was observed. Other sources of topographic disturbance include power lines, cattle trails and wallows.

## The Prehistoric Period (Ca. 6000 B.C. - 1770 A.D.)

The first task of the present historical survey was to determine the potential for encountering archaeological resources from the prehistoric period within the confines of the subject parcel. When the Spanish first explored northern California in the latter part of the eighteenth century, the region possessed what has been described as "the densest Indian population anywhere north of Mexico" (Margolin 1978:1). It has been estimated that between 7,000 and 10,000 native Californians inhabited the naturally fruitful coastal area between Point Sur in Monterey County and the San Francisco Bay (Kroeber 1925:464).

Much of this aboriginal population must have been situated along the eastern shoreline of the San Francisco Bay; for by all accounts, the region, in its natural state, was one of the richest, most bountiful natural environments in California. Before the onset of large scale Anglo-American immigration and development in the second half of the nineteenth century, the present subject area and its surroundings consisted of a largely level grassy plain; impressive stands of oak trees were scattered throughout the area. From the shoreline of the Bay, the ground rose sharply toward the east. In the hills above the future towns of Oakland, Berkeley and San Leandro, there existed a magnificent stand of redwoods: some of these trees are said to have exceeded thirty feet in diameter and three hundred feet in

height (Gibbons 1893; Burgess 1951). These redwoods were so prominent and conspicuous that Gold Rush era sea captains used the tallest trees as navigational landmarks upon entering the Golden Gate some sixteen miles to the west (Bagwell 1982:15). The region was watered by several large creeks that flowed from the hills into the Bay. In the spring, the fertile ground was covered as far as the eye could see by California poppies and other wild flowers (ibid:3). Deer, rabbits, wildcats, raccoons, grizzly bears and numerous small animals abounded throughout the area. Wildfowl flourished around the various streams and marshes scattered throughout the region.

Native American shellmounds -- massive heaps of ash, shell and cultural refuse -- once dotted the shoreline and adjacent inland areas of the San Francisco Bay. When N.C. Nelson conducted the first intensive archaeological of the region in 1908, he recorded no less than four hundred and twenty-five aboriginal shellmounds on or near the shoreline of the bay (Nelson 1909). Numerous other archaeological sites, containing the material remnants left by the region's numerous Native American inhabitants were located in the hills to the east of the Bay's original shoreline.

With this introduction to the prehistory of the San Francisco Bay area, we now turn to the evidence at hand for the proposed Buckhorn Reservoir site.

The project area is situated in the territory which, at the beginning of the historic period, was occupied by the Costanoan Indians (see Key to Tribal Territories Map" in Heizer 1978: ix). The populous Costanoans inhabited a bountiful natural environment and, as we have seen, left behind a prolific archaeological record. With this in mind, A.L. Kroeber noted the following:

> The entire Costanoan frontage on ocean and bay is lined with shell deposits. San Francisco Bay in particular is richer in such remains than any other part of the state, except perhaps the Santa Berbara Islands (1925:466).

Ethnographic and archaeological summaries of the Costanoans can be found in the following sources: The Handbook of North American Indians, volume 8 (see Levy 1978:485-495), the Handbook of California Indians (Kroeber 1925:462-473, California Archaeology (Moratto 1984), The Archaeology of California (Chartkoff and Chartkoff 1984) and The Ohlone Way: Indian Life in the San Francisco - Monterey Bay Area (Margolin 1978).

Archival research revealed that no archaeological sites of either prehistoric or historic period age or character have been recorded within the confines of the proposed Buckhorn Reservoir site: nor had any archaeological sites been recorded within a one mile radius of the 1601 acre subject property.

Between May and July, 1987, the staff of Archeo-Tec, under the supervision of the present writer, conducted an intensive

archaeological surface reconnaissance of the proposed Buckhorn Reservoir site. The results of this research are contained in two reports prepared by the present writer entitled A Literature Search and Archaeological Surface Reconnaissance of the Proposed High Buckhorn Reservoir, Alameda and Contra Costa Counties, California, and A Supplementary Literature Search and Archaeological Surface Reconnaissance of the Proposed Buckhorn Reservoir, Alameda and Contra Costa Counties, California (Archeo-Tec 1987a; 1987b).

The on-site surface reconnaissance of the proposed High Buckhorn Reservoir Project encountered two distinct archaeological sites within the subject property -- one of historic period age and characteristics, and another adjacent site of prehistoric and/or proto-historic affinities. These two archaeological sites have been respectively designated CA-Ala-481 and CA-Ala482H, respectively. Site records and other information pertaining to these archaeological sites are now on file at the Northwest Information Center at Sonoma State University in Rohnert Park, California.

CA-Ala-481 is located along Kaiser Creek and Kaiser Creek Road. As observable from archaeological surface manifestations, the site is characterized by four bedrock mortar features, consisting of two sandstone boulders, each with a single cup, situated on the west side of Kaiser Creek, and two other sand-

stone boulders respectively featuring two mortar cups and a grinding slick within the Kaiser Creek channel. In addition to the four bedrock mortar features, one definite pecked rock art element was recorded on a sandstone boulder on the east side of Kaiser Creek, as well as several possible grooved elements on the west side.

CA-Ala-482H is an historic period archaeological site consisting of a single-course stone foundation fabricated of locally available sandstone forming a rectangle with a south facing entrance. Two adjacent depressions may represent the remnants of out-buildings and/or trash pits. A variety of historic period artifacts were observed in close proximity to these architectural features, including a metal stove part, several rusted metal pipes, white "ironstone" ceramic fragments, and numerous shattered glass bottles. One glass bottle base was embossed with a registration date of 1882 (Godden 1964).

As noted above, archaeological sites CA-Ala-481 and CA-Ala-482H were found in close physical proximity to one another, and the possibility that these two sites may be either temporally and/or functionally associated in some way could not be ruled out on the basis of the evidence acquired from surface archaeological reconnaissance.

<u>The Historic Period (1770 - Present)</u>

The East side of the San Francisco Bay was first explored by the Portola expedition in 1769-70; a few years later, in 1772, Pedro Fages made a more thorough survey of the region (Conmy 1961:3). Between the appearance of the first Spanish ship to sail through the Golden Gate (the San Carlos under the command of Lieutenant Juan Bautista de Ayala), and the discovery of gold at Sutter's Mill, the East Bay region remained almost entirely undeveloped and uninhabited by Europeans. During this period, population and maritime traffic were extremely limited throughout the San Francisco Bay area. The Presidio at San Francisco was officially founded on the site near the Golden Gate in September, 1776, in a place convenient for the emplacement of an artillery battery at the narrowest part of the harbor entrance. A month later, the Mission was founded at the Laguna de los Dolores (Olmsted, Olmsted and Pastron 1977:257). Throughout the remainder of the eighteenth century, the eastern shore of the bay was occupied solely by its Native American inhabitants.

Luis Maria Peralta was the first individual of European ancestry to be associated with the East Bay region. Born in Tubac, Sonora, Mexico, Don Luis Peralta came to California with his parents as part of the Anza expedition in 1775. About six years later, he enlisted in the military service at the Presidio of Monterey; for most of his career, however, he served and resided at the Presidio at San Francisco. In 1820, Don Luis Peralta retired from the military, and as a reward for years of

faithful, dedicated service to the King of Spain, Don Pablo Vicente de Sola, the Governor of Alta California, granted him a tract of land of eleven leagues (44,800 acres) extending from San Leandro Creek on the southeast to El Cerrito Creek on the northwest.

Don Luis Maria Peralta named his vast holdings Rancho San Antonio (Halley 1876:39). All of the present-day communities of Oakland, Berkeley, Piedmont, Albany, Emeryville, Alameda as well as the northern part of San Leandro were contained within Don Luis Peralta's land grant. Hence, the southeastern corner of the vast Rancho San Antonio encompassed the Alameda County portion of the present Buckhorn Reservoir site.

Don Luis Peralta never made his home within the vast Rancho San Antonio, and for more than twenty years the land remained unoccupied, except for the activities of his sons, a few vaqueros and a small number of Indian workers (Conmy 1961:4).

Don Luis Peralta and his wife Maria had seventeen children, nine of whom survived into adulthood (Bagwell 1982:11). Before he died in 1851 at the age of 93, Don Luis Peralta divided the Rancho San Antonio between his four sons (Thompson and West 1878:19). Rancho San Antonio was parceled out in the following manner:

The lands commencing at the southeastern boundary of

> San Leandro Creek were given to Ignacio [whose] estate extended to approximately where Seminary Avenue now is. Ignacio Peralta, baptized Hermenegildo Ignacio, was born April 13, 1791 and died May 9, 1874 at the age of 85 years.
>
> To Antonio Maria Peralta, his father gave the lands which generally comprise the area from the present Seminary Avenue line to Lake Merritt. He built his home in the foothills overlooking the present Fruitvale district. He was born on August 16, 1801 and died on February 22, 1879, at the age of 78.
>
> Vicente Peralta, baptized Jose Vicente, was given the area running from the southern end of Lake Merritt down to the bay on the west, and thence following the bay shore beyond the present Temescal district. All of the original [town of] Oakland was within Vicente Peralta's estate. He was born on November 21, 1812 and died on June 30, 1871, at the age of 59.
>
> The fourth son, Jose Domingo, was given the northwestern area, including the present cities of Berkeley and Albany and also in its southern extremity a small portion of the present city of Oakland. Jose Domingo Peralta was born December 3, 1795 and died on April 3, 1865 at the age of 70 years (Conmy 1961:4).

As we have seen, that part of the Buckhorn Reservoir site situated within Alameda County fell within the lands granted by Don Luis Peralta to his son Ignacio. The Contra Costa County portion of the subject parcel was located on the periphery of <u>El Rancho de la Laguna de los Palos Colorados</u>, granted to Joaquin Moraga by the Mexican authorities in 1841.

Each of the four Peralta sons settled upon his respective portion of Rancho San Antonio. Like his brothers, Ignacio Peralta built an adobe and settled his vast holdings. Ignacio Peralta's original house was located within the present city of San Leandro, well to the west of the Buckhorn Reservoir project

site. Jacob Bowman describes the manner of life on the early California ranchos:

> On the ranchos of the bay counties the number and locations of the adobes varied. At most ranchos there was only one adobe at the homestead, but on others one or more buildings were erected within a few feet or at some distance from the first dwelling. As the sons and daughters of the owners married, they built their adobes nearby or on more distant parts of the ranchos. Between 1820 and 1842 adobes were erected by the Bernal family on Rancho Santa Rita, the Higueras on Rancho Milpitas, the Younts on Rancho Caymus, the Martinez children on Rancho Pinole, and the Peralta sons on Rancho San Antonio (1951:59).

Like almost all of the landed Spanish families in Alta California, the Peraltas made their living from agriculture and animal husbandry (De Veer 1924:34-35). The four Peralta brothers grew a variety of crops and raised cattle on their respective portions of Rancho San Antonio. There was also a considerable amount of logging, especially in the stands of redwoods which dominated the hills overlooking the future city of Oakland (Conmy 1961:6). However, the great economic and social development of the East Bay region would await the coming of the Americans who, within a relatively brief span of time, would change the face of the area forever.

Historical research revealed that Ignacio Peralta never inhabited or developed the parcel of land under consideration in this report. As we have seen, his house was situated well to the west of the present Buckhorn Reservoir project area. Indeed, there is no record of any adobes ever existing on the property during the early historic period (Hendry and Bowman 1940:586)

Further, there is no evidence whatever that any of the activities of the Peralta family, or those of the Moragas in Contra Costa County, resulted in any significant impact upon the present subject property. This finding is not surprising considering the relatively scarce and scattered population in the East Bay region throughout the period of Spanish/Mexican hegemony over the region. Jacob Bowman notes that a total number of 115 adobes were built within the confines of present day Alameda County during this period, and an additional 57 structures were erected in what today is Contra Costa County (1851:59).

The town of San Francisco -- or Yerba Buena as it was then called -- was founded in 1835 when an Englishman named W.A. Richardson pitched a tent near present day Portsmouth Square (Watkins and Olmsted 1976:14). For the next decade and a half, the little town of Yerba Buena grew steadily, if unspectacularly. During this time, Rancho San Antonio remained exclusively in the hands of the Peralta family. It was not until the Gold Rush era that American settlers in Northern California first cast their eyes upon the fertile but undeveloped lands on the east side of the San Francisco Bay.

Beginning in 1849, an increasing number of Anglo-Americans found their way onto the Peralta estate. As early as 1846, William Heath Davis, one of San Francisco's prominent early citizens, recorded the following observation:

> In my travels around the bay on business, I had observed a picturesque spot for a town on the estuary of San Antonio, due east from San Francisco. The site was known in early times as Encinal de Temescal, on Vicente Peralta's portion of the division of the Ranch San Antonio, segregated by Don Luis Peralta, his father. The site is the present city of Oakland (Davis 1889:251).

Davis was one of the first of many Americans to recognize the commercial potential of Vicente Peralta's property, and he claims to have made an attempt to purchase a portion of the Rancho San Antonio:

> My relation with Don Vicente was good, socially and commercially. In the fall of 1846 he was in my store making purchases. I told him I had a proposition to make for his consideration, and I desired for him to dine with me that evening. After dinner, I broached the matter by saying to him, "you are the owner of the Encinal de Temescal and there is a spot on that part of your rancho that please me for a town." He wanted to know the exact location of the place, and I pointed it out to him on a rough map I had prepared for the purpose. I offered him $ 5,000 cash for two-thirds of the Encinal, to build a church of his faith, also to construct a wharf and run a ferryboat from San Francisco to the intended town, all of which to be at my cost and expense. Whenever sales of lots were made, we would both sign the deeds and each take his pro rata of the money. Don Vicente, in reply to my talk, said that he would take the matter under advisement and let me know (ibid).

Hoping to keep his part of the Rancho San Antonio intact, Don Vicente Peralta decided to decline Davis' offer. However, the tide of American immigration could not be stemmed. Soon, an increasing number of brash squatters began to settle on Vicente Peralta's property, pitching tents and erecting shacks, hunting game, planting crops and occasionally poaching Peralta cattle.

Although the pace was slower, a similar situation was taking place within Ignacio Peralta's portion of Rancho San Antonio. Contra Costa County was officially founded in 1851 (Purcell 1940), and Alameda County in 1853 (Wood 1883). Anglo-Americans were soon settling in the area where the city of San Leandro exists today.

In spite of the transfer of authority over California from Mexico to the United States, and the resultant increase in Anglo-American immigration to the East Bay region, the Peralta Brothers managed to keep their estates largely intact until the close of the 1850s. For example, on February 3, 1858, Ignacio Peralta's claim to his 9416 acre estate was validated by the American courts (Conmy 1961:5; Wood 1883:335).

However, the Anglo-American tide could not be stemmed indefinitely and, over the years, the Peralta family reluctantly sold off portions of their vast estates in the East Bay region. Litigation concerning the ownership of portions of Rancho San Antonio continued until 1885, but "long before that the great Rancho was gone -- broken up into farms and townships" (Fibel 1971:21). The following passage describes the end of the Peralta era as the most prominent family of the East Bay region:

> Rancho San Antonio went the way of the missions, into legend. The disillusioned Peraltas were eventually reduced to living on small lots, where finally reconciled, they tried to emulate the <u>Americanos</u>... Ignacio built a red brick house in 1860... in San Leandro.

This is said to be the first brick house built in Alameda County and is now the Alta Mira Club House with a California Historical Landmark designation # 285 (Fox 1975:67).

Ignacio Peralta died in 1874, and after this date the dispersal of what remained of his estate accelerated. A detailed check of maps, oral accounts and other documentary sources for the second half of the nineteenth century, failed to uncover any specific historical documentation regarding the development of that part of the Peralta estate contained within the present Buckhorn Reservoir project area. However, as we have seen, archaeological surface reconnaissance encountered the foundations of an historic period structure and associated features, now identified by the designation CA-Ala-482H, that may possibly date from the last years of Peralta ownership of the Alameda County portion of the subject property. Based on observable surface characteristics, the structural remains in question were standing in the late 1870s or early `80s and may have been erected considerably earlier. It is possible that this structure was associated with the Peralta family's cattle grazing activities; alternatively, this structure may have provided shelter for one of the many squatters who had established themselves on the Rancho San Antonio during this period, or it may have been built by a subsequent owner or tenant. Unfortunately, there is at present insufficient historical or archaeological evidence to support any of these suppositions. What is certain, however, is that these archaeological remains represent the earliest tangible

remainder of historic period activity within the confines of the proposed Buckhorn Reservoir site (see Archeo-Tec 1987a; 1987b).

A detailed recitation of the often tangled web of changes in ownership of the various portions of Ignacio Peralta's former estates, as well as that of Joaquin Moraga, during the second half of the nineteenth century and early decades of the twentieth lies beyond the scope of the present report. Suffice it to state that throughout this period title to the various portions of the once unified Rancho San Antonio, including the present Buckhorn Reservoir Site, passed to other individuals. However, documentary research revealed that throughout this period, the present project area and its immediate surroundings remained virtually undeveloped, and use of the land was limited to cattle grazing and related activities.

The association between the project sponsor, the East Bay Municipal Utility District (EBMUD) and the present subject area and its surroundings can be traced as far back as the first quarter of the twentieth century. As early as 1923, EBMUD began acquiring lands in the upper San Leandro watershed area, including the present Buckhorn Reservoir site. Between 1923 and 1952, a EBMUD adopted a total of 78 resolutions regarding the acquisition of property in the Upper San Leandro watershed area (Data on file at the EBMUD library in Oakland, California).

Today, as we have seen, the Buckhorn Reservoir site remains in a relatively pristine condition, one of the few parts of the East Bay that is still largely unchanged from the days of the Peralta and Moraga families and their regional antecedents, the Costanoans.

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Historical Overview of the Proposed Pinole Reservoir Site
Contra Costa County, California

Submitted to:

EIP Associates
319 Eleventh Street
San Francisco, California 94103

Submitted by:

Archeo-Tec
114 Wilding Lane
Oakland, California 94618
25 August 1987

## Site Location and Description

At the request of Mr. John Davis of EIP Associates in San Francisco, Allen G. Pastron, Ph.D, of Archeo-Tec has conducted an archival survey of the history of the proposed Pinole Reservoir site, located on Pinole Creek, approximately 1 mile southeast of the City of Pinole, in Contra Costa County, California. The principal goals of the present report are to provide a general overview of the history of the project site and to describe the uses to which the property has been put from prehistoric times through the twentieth century. To develop the Pinole Reservoir, the project sponsor, the East Bay Municipal Utility District (EBMUD), proposes to construct a dam and associated facilities and inundate an area of approximately 860 acres.

The subject property is primarily characterized by gently rolling grasslands, ranging between 200 and 340 feet in elevation. Dominant vegetation consists primarily of introduced grasses, with cluster thistle, introduced cardoon and milk thistle, poison oak, mustard and numerous wild flowers, including California poppy, genians and centuries. Horehound occurs locally, and chia is locally abundant. Small stands of California scrub oak are scattered sporadically throughout the project area, as are Blue Oak, Buckeye, *Prunus* sp., and Sitka Willow.

Pinole Creek courses in a westerly direction through the center of the project area. This, as well as a number of unnamed feeder tributaries are lined with dense riparian foliage, including the above noted trees as well as Pacific Willow, Bay laurel, Big Leaf Maple and Pacific Madrone; blackberry thickets and poison oak were noted within the riparian zone as were clusters of cattail, rushes, watercresses and mosses. In places, these thickets are so dense as to inhibit crossing the steep-sided ravines.

Dominant site geology consists primarily of soft, weathered sandstones which outcrops only rarely throughout the project area. Dominant soils throughout the project area are sandy clays which range in color according to depth, from rich brown top soil near the ground surface to yellow sandy clay beneath.

Present usage of the proposed Pinole Reservoir site is primarily devoted to cattle grazing. However, the eastern half of the project area, south of Pinole Creek Road, is presently used for the cultivation of oats, wild wheat and vetch.

Moderate alteration to the original landscape has occurred in the recent past. South of Pinole Valley Road, the eastern part of the subject property has been subjected to intensive tilling and cultivation during the past several decades. Several residential structures, as well as a barn and a stable, exist

within this portion of the subject property; there is also a network of graded dirt roads. Still within the eastern part of the subject property, the level of disturbance is less marked north of Pinole Valley Road: several stables and dirt roads represent the only modification of the original landscape within this part of the rcsearch area.

The northern area of the proposed Pinole Reservoir site contains five marshy ponds, only one of which is noted on the USGS topographic map, (Briones Valley 7.5'). Earthen levees in the vicinity of these ponds suggest considerable localized disturbance to topsoil. A single aluminum barn, two large water tanks and a windmill were noted within this part of the project site. Numerous dirt roads are scattered throughout the property. With the exception of the above noted earthen levees, disturbance is minimal within this portion of the project area.

With the exception of the areas south of Pinole Valley Road and east of Castro Ranch Road, the western part of the proposed Pinole Reservoir site is the most pristine portion of the subject property. Within this area, localized dumping of construction rubble, a residential structure, a graded dirt road and a Christmas tree farm have altered the original landscape to a degree.

<u>The Prehistoric Period (Ca. 6000 B.C. - 1770 A.D.)</u>

The first task of the present historical survey was to determine the potential for encountering archaeological resources from the prehistoric period within the confines of the subject parcel. When the Spanish first explored northern California in the latter part of the eighteenth century, the region possessed what has been described as "the densest Indian population anywhere north of Mexico" (Margolin 1978:1). It has been estimated that between 7,000 and 10,000 native Californians inhabited the naturally fruitful coastal area between Point Sur in Monterey County and the San Francisco Bay (Kroeber 1925:464).

Native American shellmounds -- massive heaps of ash, shell and cultural refuse -- once dotted the shoreline and adjacent inland areas of the San Francisco Bay. When N.C. Nelson conducted the first intensive archaeological of the region in 1908, he recorded no less than four hundred and twenty-five aboriginal shellmounds on or near the shoreline of the bay (Nelson 1909).

With this introduction to the prehistory of the San Francisco Bay area, we now turn to the evidence at hand for the proposed Pinole Reservoir site.

The project area is situated near the northeastern border of the territory which, at the beginning of the historic period, was occupied by the Costanoan Indians (see Key to Tribal Territories Map" in Heizer 1978: ix). The populous Costanoans inhabited a

bountiful natural environment and, as we have seen, left behind a prolific archaeological record. With this in mind, A.L. Kroeber noted the following:

> The entire Costanoan frontage on ocean and bay is lined with shell deposits. San Francisco Bay in particular is richer in such remains than any other part of the state, except perhaps the Santa Barbara Islands (1925:466).

Ethnographic and archaeological summaries of the Costanoans can be found in the following sources: The Handbook of North American Indians, volume 8 (see Levy 1978:485-495), the Handbook of California Indians (Kroeber 1925: 462-473, California Archaeology (Moratto 1984), The Archaeology of California (Chartkoff and Chartkoff 1984) and The Ohlone Way: Indian Life in the San Francisco - Monterey Bay Area (Margolin 1978).

Archival research revealed that no archaeological sites of either prehistoric or historic period age or character have been recorded within the confines of the proposed Pinole Reservoir project area.

Between May and July, 1987, the staff of Archeo-Tec, under the supervision of the present writer, conducted an intensive archaeological surface reconnaissance of the proposed Pinole Reservoir site. The results of this research are contained in two reports prepared by the present writer entitled A Literature Search and Archaeological Surface Reconnaissance of the Proposed High Pinole Reservoir, Contra Costa County, California, and A

Supplementary Literature Search and Archaeological Surface Reconnaissance of the Proposed Pinole Reservoir, Contra Costa County, California (Archeo-Tec 1987a; 1987b).

Archaeological surface reconnaissance of the proposed Pinole Reservoir project area encountered a prehistoric midden deposit of apparently substantial dimensions. Since its discovery and formal recording, this site has been given the designation of CA-CCo-549. On the basis of surface indications, CA-CCo-549 appears to represent an extensive and significant habitation site. Unfortunately, few other details concerning the areal extent or specific archaeological characteristics of this midden deposit are presently available.

In addition to CA-CCo-549, the Archeo-Tec survey team identified a cultural isolate -- in the form of a large shell fragment -- at a place where a local resident claimed to remember the presence of an archaeological site. This cultural isolate has now been officially designated CCo-Iso-12. The land in the immediate vicinity of CCo-Iso-12 was under cultivation at the time of Archeo-Tec's April, 1987 survey, and it was unfortunately impossible to determine at that time if other surface or subsurface cultural resources were associated with the isolated shell fragment that was encountered.

Information regarding the recently discovered prehistoric

cultural resources within the confines of the proposed Pinole Reservoir site is on file at the Northwest Information Center at Sonoma State University, and at the offices of Archeo-Tec.

## The Historic Period (1770 - Present)

The East side of the San Francisco Bay was first explored by the Portola expedition in 1769-70; a few years later, in 1772, Pedro Fages made a more thorough survey of the region (Conmy 1961:3). Between the appearance of the first Spanish ship to sail through the Golden Gate (the San Carlos under the command of Lieutenant Juan Bautista de Ayala), and the discovery of gold at Sutter's Mill, the East Bay region remained almost entirely undeveloped and uninhabited by Europeans. During this period, population and maritime traffic were extremely limited throughout the San Francisco Bay area. The Presidio at San Francisco was officially founded on the site near the Golden Gate in September, 1776, in a place convenient for the emplacement of an artillery battery at the narrowest part of the harbor entrance. A month later, the Mission was founded at the Laguna de los Dolores (Olmsted, Olmsted and Pastron 1977:257). Throughout the remainder of the eighteenth century, the eastern shore of the bay was occupied solely by its Native American inhabitants.

The first white settler in the area of the present day city of Pinole was Ignacio Martinez, one of the most respected early

Spanish settlers in _Alta_ California. Purcell describes Don Ignacio Martinez and his arrival in the Pinole Valley region:

> Commandante Don Ignacio Martinez, one of the most aristocratic of the Spanish dons of early California, was chief military officer of the presidio of San Francisco in 1823 when he received possession of Rancho El Pinole in Contra Costa. To fulfill the requirements upon which grants were made by the government he proceeded to build a home and other houses of adobe in the valley of Pinole, brought cattle and other property and made improvements of a similar kind (1940:142).

A description of this early historic period settlement of the Pinole Valley region is provided by a volume entitled _Illustrations of Contra Costa County_, first printed in 1879 by the Contra Costa Historical Society:

> During the year 1823 Francisco Castro made application to the Mexican authorities for the San Pablo Rancho, and Ignacio Martinez for the Pinole Rancho, to the extent of four leagues of land each. These men, who were the pioneer white settlers on our county, planted vineyards and pear orchards at their ranchos more than half a century ago. They made other little improvements; each of them built an adobe house and a few corrals. Their neighbors were the families of Peralta at San Antonio, and Castro at San Lorenzo, until about the year 1826, when Jose Maria settled upon the San Ramon Rancho (at Dublin), where he obtained a grant of four leagues of land (1952:11).

An examination of maps and other historic documents confirms that the present Pinole Reservoir site lies within the boundaries of Ignacio Martinez' Rancho Pinole. The volume _Illustrations of Contra Costa County_ provides a fascinating glimpse into the patterns of everyday life on Rancho Pinole and adjacent settlements:

> The ranch owners usually had employed a few vaqueros to herd and take care of their stock. The vaqueros were generally Mission or Christianized Indians... Although deprived of society and comparatively alone, the people

> were generally contented and apparently happy. The ranch owners were very hospitable at their homes... Very little attention was given to agricultural pursuits... [other] than that nearly every ranch owner had cultivated a few acres of beans and corn, and a small potato patch, with a few other vegetables, and a few rods square planted in melons. This was about the extent of farming carried on at the different ranches. Almost all of the rancheros, when locating their ranches, planted small vineyards, and many of them a few pear trees. Many of these vineyards and trees bear fruit to this day (ibid).

Ignacio Martinez' adobe was located well to the west of the Pinole Reservoir site, near the present day city of Pinole. Apparently, none of Contra Costa County's early historic period adobes were situated within the confines of the proposed Pinole Reservoir site (Hendry and Bowman 1940): similarly, archival research produced no evidence that any of the major economic or social activities that occurred at Rancho Pinole were conducted within the confines of the present project area. As far as can be determined from documentary research, the greater part of Rancho Pinole, including the entirety of the present research area remained in an essentially pristine state throughout the ownership of the property by the Martinez family. This finding is really not surprising considering the relatively scarce and scattered population in Contra Costa County throughout the period of Spanish/Mexican hegemony over the region. Jacob Bowman notes that a total number of 57 adobes were built in what today is Contra Costa County, with an additional 115 structures erected in adjoining Alameda County (1851:59).

With the discovery of gold in the Sierra Nevada foothills

in 1849, an ever increasing number of Anglo-Americans found their way to the eastern shore of the San Francisco Bay and settled in what today is Contra Costa County. The County was formally founded in 1851. In spite of the transfer of authority over California from Mexico to the United States, and the resultant increase in Anglo-American immigration to Contra Costa County, the Martinez Brothers managed to keep their estates largely intact until the close of the 1850s. The Martinez land grant of 17,786.49 acres was validated by American courts on October 24, 1854 (Purcell 1940:143).

By the mid-1860s, Contra Costa County was changing, and Purcell describes the acquisition of Rancho Pinole by the Tormey family:

> In 1865, John and Patrick Tormey acquired large portions of Rancho El Pinole. Jointly they bought 7,000 acres, which embraced all the land facing San Pablo bay from the town of Pinole to and including the Western half, which took in Pinole itself, the original adobe hacienda of the Martinez family in Pinole valley and many additional acres in Pinole and Briones valleys now owned by the Fernandez estate, EBMUD, Atlas Powder Company, Cole estate and others. John Tormey built a very fine home in one of the prominent sections of his domain. The house is now a landmark owned by the East Bay Municipal District (1940:143).

Another documentary source also notes the transfer of ownership of the major part of Rancho Pinole in the mid-1860s from the Martinez' to the Tormey family:

> Mrs. John Tormey owns about 3,000 acres of the Pinole ranch, originally four leagues of land granted to Ignacio Martinez. The residence is situated in a romantic valley, through which passes Pinole Creek. It is about eight miles from Martinez and the same from

Pinole Station (Contra Costa Historical Society 1952:35).

In addition to the Tormeys', who purchased a large portion of the former Martinez property, other people were acquiring less extensive parcels of land in the area and establishing small farms during the second half of the nineteenth century. One such individual was Joseph Pfister, who had previously operated a colorful adobe lodging house in the town of Benicia during the late 1840s and `50s:

> In 1866 Jos. Pfister bought his present home of 160 acres, where he can raise a crop whether the season be wet or dry. The farm is fenced off into four sections, the residence is a two-story frame building, surrounded by a beautiful garden and orchard. A large and commodious barn is situated about 150 feet from the dwelling, and is capable of holding about 30 tons of hay. Water is supplied by an artesian well. The farm is about one mile from Pinole station and the wharf, thus affording two very convenient facilities for shipping farm productions (Contra Costa Historical Society 1952:34).

It should be noted that there is no evidence to suggest that Mr. Joseph Pfister's property was located within the confines of the proposed Pinole Reservoir site; however, since his activities seem to typify the general demographic trends occurring in this part of Contra Costa County during the second half of the nineteenth century, they are included here.

In the 1870s, large segments of the former Martinez Rancho was acquired by the Fernandez family. Believing that the area possessed great potential for growth and prosperity, Mr. Fernandez made his home near the present day city of Pinole in antici-

pation of the region's future growth; this aspect of local history is described by the Contra Costa Historical Society:

> B. Fernandez owns the most valuable portion of this little village at the mouth of the rich and beautiful Pinole Valley, which has, by the construction of the railroad, come into very important notice. Its nearness to the metropolis, and fine situation for a village, must, in the near future, make the place much sought after for suburban residences. There are many desirable building sites in this neighborhood, which are certain to be occupied, and a large village will grow up here as soon as its advantages become known (Contra Costa Historical Society 1952:34).

In addition to his interests near the present day city of Pinole, Mr. Fernandez also acquired a substantial tract of property in the vicinity of the proposed Pinole Reservoir site.

Throughout the second half of the nineteenth century, alterations to the natural landscape in the vicinity of the proposed Pinole Reservoir site remained minimal. The area was almost exclusively devoted to cattle grazing and, apparently, a limited amount of agriculture. Only a few scattered structures had been erected throughout the area.

Other than the general overview presented above, a detailed recitation of the lengthy list of changes in ownership of the various portions of Ignacio Martinez' former estate during the second half of the nineteenth century and early decades of the twentieth lies beyond the scope of the present report. Suffice it to state that throughout this period title to the various portions of the once unified Rancho Pinole, including the

present Pinole Reservoir Site, passed to other individuals.

The association of the East Bay Municipal Utility district with the subject property formally began on August 7, 1946, when the Chief Engineer of EBMUD authorized a plan for the acquisition of lands for the proposed Pinole Reservoir. Two resolutions were subsequently enacted, one dated December 14, 1956, the other dated December 20, 1957. Both of these resolutions referred to the actual purchase of land for the proposed reservoir.

Today, as we have seen, the proposed Pinole Reservoir site remains in a relatively natural state, one of the few parts of the East Bay that still resembles that natural topography familiar to Ignacio Martinez and the original inhabitants of the region, the Costanoans.

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# Appendix E
# Recreation Plan

# CURRENT AND FUTURE

# RECREATIONAL OPPORTUNITIES

# IN THE

# UPPER SAN LEANDRO

# AND PROPOSED

# BUCKHORN RESERVOIR

# WATERSHEDS

Watershed and Recreation Division
August, 1988

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## I. CURRENT AND FUTURE RECREATIONAL OPPORTUNITIES

### Water Supply Management Program Objective

The Water Supply Management Program considers two alternatives that include increasing the District's local terminal reservoir storage capacity. Of the two new reservoirs under consideration, the Buckhorn dam and reservoir project offers significant recreational opportunities due to its close proximity to Upper San Leandro Reservoir and the cities of Moraga, Castro Valley, San Leandro, and Oakland.

### Watershed Ownership

The Upper San Leandro and Buckhorn Reservoir watersheds include approximately 9,000 acres of land and water. The District currently owns 7,640 acres of these watershed lands and, as part of the project mitigation, is proposing the acquisition of the remaining watershed lands currently in private ownership. Less than 100 of these acres are within the proposed inundation area for Buckhorn Reservoir. These acquisitions would ensure that the watershed lands would remain undeveloped and that the high quality of stored water could be maintained into the future.

### Current Recreation

The watershed lands of Upper San Leandro and Buckhorn Reservoir and the waters of Upper San Leandro Reservoir are closed to the general public. The boundary of this watershed is enclosed by barbed wire fencing and posted against loitering and trespassing. To ensure compliance these watershed lands are patrolled by peace officers of the East Bay Regional Park District under guidelines contained in a Joint Powers Agreement with the utility district. Exceptions to the "closed" status are made for limited access to permit holders in three classifications: natural resource research, environmental education, and trail use. As a result of these controls, the pristine character and scenic value of these lands has been preserved.

### Current Recreation Facilities

No recreation facilities exist on Upper San Leandro Reservoir. The Valle Vista Staging Area is located on Canyon Road approximately 1/2 mile west of the City of Moraga. This area includes an unsurfaced parking area, outdoor toilet facilities, and trail signage for hiking and equestrian trail users with valid EBMUD Trail User Permits.

Approximately 22 miles of hiking and equestrian trails run from Valle Vista Staging Area across the Upper San Leandro, Buckhorn, and Chabot Reservoir watersheds to connect with regional trails owned, operated and maintained by the East Bay Regional Park District. See Exhibit-1 for current and proposed watershed trails.

### Relocation of Current Recreation Facilities

A short section of the Rocky Ridge Trail would be inundated by the filling of Buckhorn Reservoir necessitating relocation of the trail around the eastern and northern edge of the proposed reservoir. Refer to Exhibit-1 for the relocated section of the Rocky Ridge Trail.

## II. PRELIMINARY UPPER SAN LEANDRO AND BUCKHORN RESERVOIR RECREATION PLANS

### Watershed Hiking and Equestrian Trails (Unsurfaced)

Approximately 30 miles of additional hiking and equestrian trails and wilderness rest stops are proposed for the Upper San Leandro and Buckhorn Reservoir watershed lands. See Exhibit-1 for the alignment of the proposed trails and rest stop placement. Additional signage will be provided to ensure that permit holders remain on those trails and/or fire roads open to hikers and equestrians. Standard District Trail Use Rules and Regulations will apply to the proposed expansion trails.

### Bicycle Trail (Surfaced)

It is proposed to pave Miller Road from its intersection with Redwood Road to the crest of the Upper San Leandro Reservoir Dam, a distance of approximately three miles. This road would be the main entry and exit roadway for vehicles entering the proposed San Leandro Reservoir Recreation Area. This roadway would be sufficiently wide to allow for two lanes of traffic plus standard bicycle lanes on each side. Parking racks for security of privately owned bicycles are proposed for the main recreation area.

### Main Recreation Area - Upper San Leandro Reservoir Dam

Rules and Regulations: Rules and Regulations for the proposed recreation area would provide for safe use speeds and vehicular parking for single vehicles, vehicles with boat trailers, and vehicles owned and/or operated by handicapped individuals. In addition they would cover the use of private boats, District-owned rental boats, fishing, picnicking, hiking and backpacking, equestrians, and nature study.

Fishing in Upper San Leandro Reservoir will be permitted provided that this can be done without endangering the unique native steelhead rainbow trout (Salmo irrideus) which resides in the reservoir. It may be possible to restrict fishing to only warm water species, although that presents significant enforcement problems. Planting the reservoir with any other rainbow trout hybrid would result in the elimination of Salmo irrideus.

If fishing is permitted, a modest Daily Fishing Access Fee ($1.00 per person, 16 years of age or older - younger persons with an adult could fish on the adult's ticket), will be charged to replenish the warm water fish species taken, for defraying the costs of administering the Fishing Access Fee Program, and for reservoir fish habitat enhancement projects. Areas of the reservoir would be buoyed off to provide protection of fish spawning and rearing areas, wildlife preserves, the Upper San Leandro Reservoir outlet tower, and the Buckhorn Reservoir Dam (See Exhibit-1 for the proposed buoyed-off areas).

### Recreation Support Facilities

The main recreation area would feature modest support facilities carefully designed and sited to emphasize the open space character and scenic values of the area, as follows (see Exhibit-2):

Development of the recreation area on the shore of the lagoon that lies between the new and old Upper San Leandro Reservoir dams. In addition, the old dam would be breached to allow for boating access between the lagoon and the reservoir.

- o Activity Center Building and Restroom Facilities - For the sale of fishing tackle and bait, the rental of rowboats with and without motors and food service.

- o Rental marina docks -- For storage, maintenance, and repair of rental rowboats.

- o Four-lane, surfaced launch ramp and 2 x 60 foot launching docks.

- o Picnic Areas (2)

  - With tables, barbecue units, and garbage cans. One area would be adjacent to the Activity Center Building and the other adjacent to the Riley Ridge Trail and single vehicle parking lot.

- o Parking Lots (3)

  - Near the top of the dam; one lot would provide parking for single vehicles without trailers and the other would accommodate vehicles with boat trailers.

  - At the base of the dam; a three-acre parking lot is proposed at the base of Upper San Leandro Dam.

- o Rowing Shell Sheds (3)

  - The rowing shell sheds now in place at Briones Reservoir would be moved to the crest of the old Upper San Leandro Reservoir Dam. The breached area of the old dam would allow for safe launching of university crew shells. Launch area docks would be allowed adjacent to the sheds.

- o Regional Trail Connector

  - The Riley Ridge Trail which begins in the main recreation area will allow for several loop trips across the Upper San Leandro, Chabot, and Buckhorn Reservoir watersheds. These trails will be available to hikers, backpackers and equestrians by permit only.

Miller Road Kiosk Entrance and Exit

The kiosk would be located on Miller Road close to its intersection with Redwood Road. It is proposed to staff the kiosk to operate two entrance lanes and one exit lane to collect parking, launching, and daily fishing access fees as established by District's Board of Directors.

## III. REGIONAL OUTDOOR RECREATION NEEDS ASSESSMENT

A statewide recreation needs analysis was completed in 1982 by the Palo Alto based Center for Continuing Study of the California Economy.

The executive summary of that report became one of the major elements of the California Recreation Plan. The objective of the analysis was to obtain current information on the recreational participation of California residents and to project future recreation activity over the twenty year period, 1980 to 2000.

The following excerpts from the analysis support the development of additional recreational facilities on the local watershed lands owned by the District.

Participation In All Activities - 1980

Californians 12 years and over engaged in 2.1 billion participation days in recreation outside the home or an average of 89 participation days per capita. Two thirds of this use took place within one hours's travel time from home and was seasonally distributed as follows:

| | |
|---|---|
| Summer | 33.1% |
| Fall | 21.8% |
| Winter | 19.6% |
| Spring | 25.5% |
| TOTAL | 100.0% |

Annual participation in recreation took place 56.6% of the time in government facilities and 43.4% in non-government facilities.

The percent of the total population 12 years and older participating in recreation varied between a high of 81.5% in summer to a low of 65.6% in fall.

Leading Recreation Activities - 1980

The ten leading activities out of 55 groups of recreation activities accounted for over 52% of the total participation in all recreation activities. These were as follows:

| | Millions of Participation Days |
|---|---|
| Jogging | 209.8* |
| Bicycling | 115.8 |
| Partying | 109.5 |
| Field Sports | 100.3 |
| Picnicking | 71.6 |
| Games | 63.9 |
| Nature Appreciation | 61.8 |
| Pool Swimming | 60.9 |
| Court Ball | 56.8 |
| Gym Sports | 51.5 |

* Jogging ranks unusually high due to the frequency of this activity to maintain physical fitness.

Recreation activities that participants desired most are outdoor, nature-type activities such as fishing, camping, hiking, backpacking, boating and horseback riding.

The mix of leading activities varied among the three types of occasions. Camping was the leading activity on overnight trips; picnicking accounted for the largest participation of all activities on one day trips; and jogging was the leading activity near home.

Recreation Trips - 1980

Californians took nearly 130 million recreation trips inside the state with an average of seven trips per capita. One-day trips totaled 80 million and overnight trips were 49.4 million. The percent of one-day and overnight trips by season was as follows:

| | One-Day | Overnight |
|---|---|---|
| Summer | 39.6% | 39.0% |
| Fall | 19.0% | 23.4% |
| Winter | 17.4% | 17.2% |
| Spring | 23.9% | 20.4% |
| TOTAL | 100.0% | 100.0% |

In the greater Bay Area there were 13.4 million person-trips with 10.4 million one day trips and 3.0 million overnight trips. Of these, automobiles were used in 93%, bus transportation was used in 3%, airplanes were used in 1% and the remaining 3% are accounted for by train, boat, walking, bicycling, and other means.

Swimming and beach activities, camping and fishing were the three leading groups designated by participants as "Want to Participate in More Often." The ten leading activities in this category were:

| | % |
|---|---|
| Swimming & Beach | 14.7 |
| Camping | 14.5 |
| Fishing | 14.1 |
| Scenic Area Visits | 9.4 |
| Hiking and Backpacking | 8.7 |
| Water Skiing | 8.1 |
| Picnicking | 7.2 |
| Historic & Cultural | 7.1 |
| Horseback Riding | 7.0 |
| Visiting Museums & Zoos | 6.6 |

Projected Socio-Economic Variables, 1980 to 2000

Percent distribution by age:

| Age | 1980 | 2000 |
|---|---|---|
| 0-11 | 17.3 | 16.9 |
| 12-17 | 9.9 | 9.0 |
| 18-24 | 12.5 | 9.6 |
| 25-34 | 17.5 | 12.9 |
| 35-44 | 13.1 | 16.1 |
| 45-54 | 10.4 | 14.8 |
| 55-64 | 9.1 | 9.4 |
| 65+ | 10.1 | 11.3 |

Percent Distribution of Household Income:

| Income Class | 1980 | 2000 |
|---|---|---|
| $ 0 - 7,000 | 14.3 | 11.4 |
| $ 7 - 14,999 | 22.2 | 17.8 |
| $15 - 24,999 | 24.7 | 22.5 |
| $25 - 34,999 | 17.3 | 17.9 |
| $35,000 & over | 21.5 | 30.4 |

Percent Distribution of Ethnic Population Groups:

| | 1980 | 2000 |
|---|---|---|
| Black | 7.2 | 6.5 |
| Asian & Other | 8.1 | 12.0 |
| Hispanic | 19.2 | 24.2 |
| White | 65.5 | 57.2 |

Total Population and Recreation Participation Projections for California:

| | Population | Recreation Participation Days |
|---|---|---|
| 1980 | 23.7 Million | 2.1 Billion |
| 1990 | 27.8 Million | 2.5 Billion |
| 2000 | 30.5 Million | 2.8 Billion |

Recreation Trends and Needs

- Participation in outdoor, nature type recreation activities are projected to increase faster than population growth while urban activities such as bicycling, field sports, partying, and pool swimming will increase at a rate less than that of population growth.

- Public Recreation suppliers are expected to be unable to keep up with projected increases in demand for recreation facilities.

- Many urban parks are avoided because they are unattractive, uninviting, and unsafe. The fear for personal safety appears to be

the most common deterrent affecting leisure behavior. The presence of crime or the perception of danger influence where and when people pursue the recreation activities they most desire. Some people, for example, will consider only daylight activities while many elderly citizens venture out only when schools are in session. Disabled people share these feelings of vulnerability.

- To meet increased demand for outdoor recreation, opportunities for activities such as fishing, camping, boating, hiking and nature appreciation need to be provided in and near metropolitan areas.

- Existing transit networks concentrate on moving people to business and shopping areas. The future need is for an expanded transportation system that will provide direct access to recreation areas in and near metropolitan areas, particularly on weekends and holidays.

- Recreation areas of the future must provide such qualities as attractive landscaping with trees and grassy open spaces, cleanliness and good maintenance of facilities, a safe, quiet and relaxing atmosphere, diverse recreational activities, and convenient location and accessibility.

- Rapidly changing social conditions are intensifying barriers to recreational activity. Examples are increasing ethnic diversity, increasing numbers of elderly persons, and the changing structure of the family. Many recreation areas reflect the current social trend of family fragmentation. Separate facilities and programs oriented toward a particular age, sex, marital status, or ability are splitting the family into separate recreation lives. The need is for facilities and opportunities that would bring families together.

- The largest increases in participation are expected in non-strenuous outdoor activities which will grow at a faster rate than the population, and could grow even faster if certain constraints are reduced. Major constraints indicate a need for nature-oriented parks, especially in highly urbanized areas. These parks will need to be designed and constructed to provide a maximum feeling of open space with a minimum of support facilities required to accommodate outdoor activities. More frequent and effective security patrols and overhead lighting will be necessary to ensure safety.

## IV. CONFORMANCE WITH DISTRICT'S LAND USE MASTER PLAN (LUMP) OBJECTIVES - 1970

The East Bay Municipal Utility District's watershed lands and reservoirs in Alameda and Contra Costa counties offer an open space resource without equal in the San Francisco Bay Area. The intangible values provided by this open space and its associated recreational activity will enhance the quality of life for residents and visitors in the East Bay area for many years to come.

The LUMP describes the results of a long-term study of the lands made jointly by EBMUD staff and the Land Resource Committee, a group of interested citizens and environmental advisors appointed by the District.

The LUMP indicates the manner in which District lands will continue to be preserved as open space and be utilized in ways compatible with their primary purpose; water production and distribution. The LUMP serves as a guide for future use and management of the lands and waters of the District for the conservation of their ecological and scenic values.

The District began acquiring land for water production and distribution soon after its creation in 1923. Major blocks were acquired in the 1920's in the East Bay and in the Sierra Nevada foothills for Pardee Reservoir. In the 1950's more land was purchased for the construction of Camanche and Briones dams and their reservoirs.

Since the 1950's the District bought specific parcels of land it needed and sold other land it did not, and now owns 54,540 acres of watershed land located in five counties with 12,765 acres of water surface.

Public demand for recreation brought the opening of Pardee Reservoir in 1958, Lafayette and Chabot Reservoirs in 1966, Camanche Reservoir in 1967, and San Pablo Reservoir in 1973.

In April, 1969 the District's Board of Directors approved a policy that set guidelines for land management and established that the primary purpose of these lands was water production and distribution, and that all other uses must be compatible with this primary purpose; stressed the importance of conserving the lands as open space; and indicated preferences for developing public access and funding of necessary recreational and operational developments.

As an initial step in implementing the LUMP, suitable land use categories were defined and potential uses were adopted in accord with the guiding principles and limitations. The five use categories include Watershed Management Preserves, for limited access open space and agricultural purposes; Recreation Management Areas, for both low and high density usage; Educational Use Areas, for a wide range of limited or public access, group or individual study, and site preservation; Public Service Areas, for possible development by various public institutions; and Unclassified Areas, for possible future development, sale or trade.

The LUMP divided the District's lands into 117 parcels - ranging in size from 7 to 3,881 acres - with 12 different types of usage in five major categories, as follows:

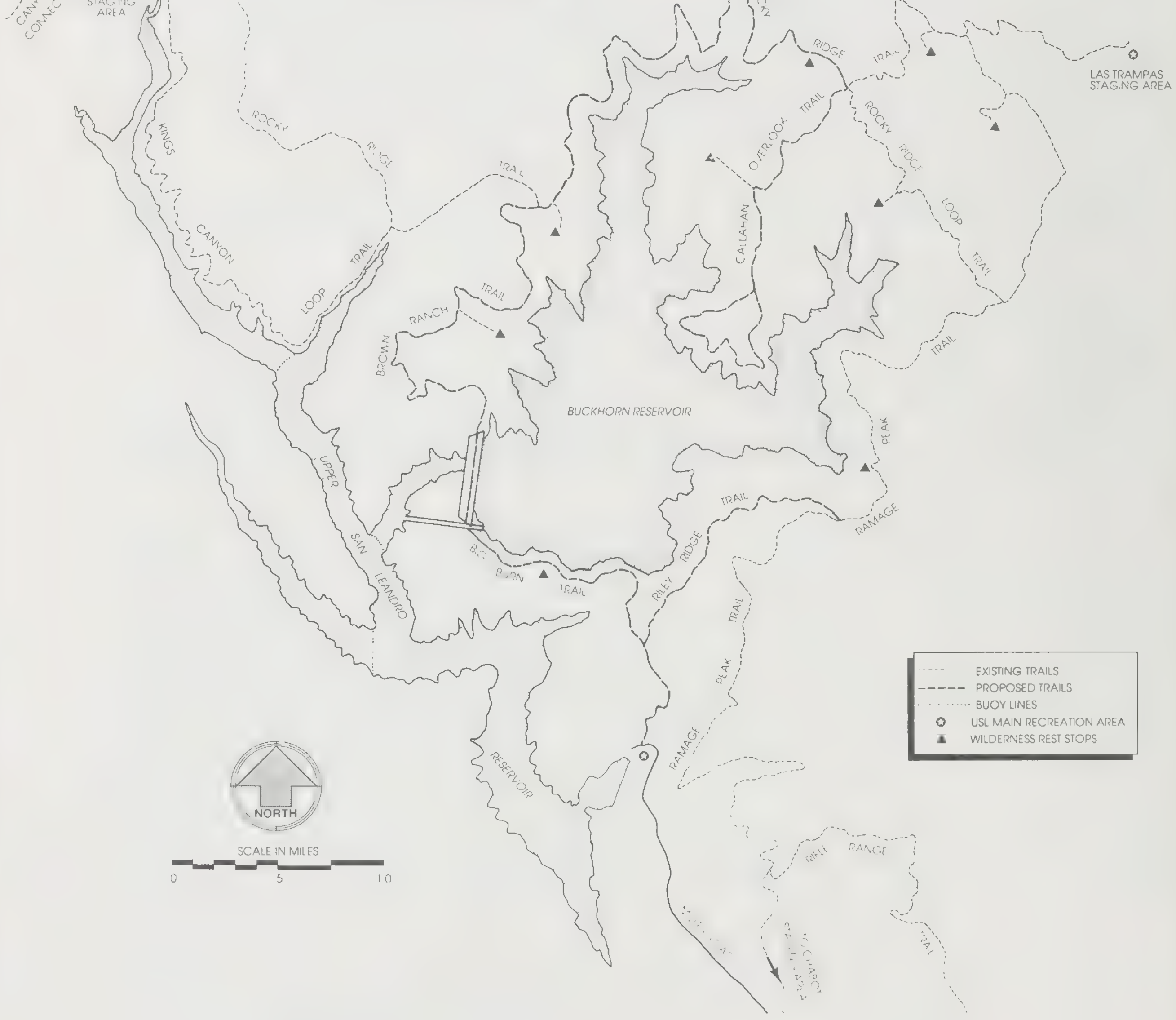
| Category | No. of Parcels | Acres* | % |
|---|---|---|---|
| Watershed Management Preserve | 33 | 24,815 | 59 |
| Recreation Management Areas | 47 | 13,805 | 33 |
| Educational Use Areas | 24 | 2,505 | 6 |
| Public Service Areas | 8 | 225 | 1 |
| Unclassified | 5 | 425 | <1 |

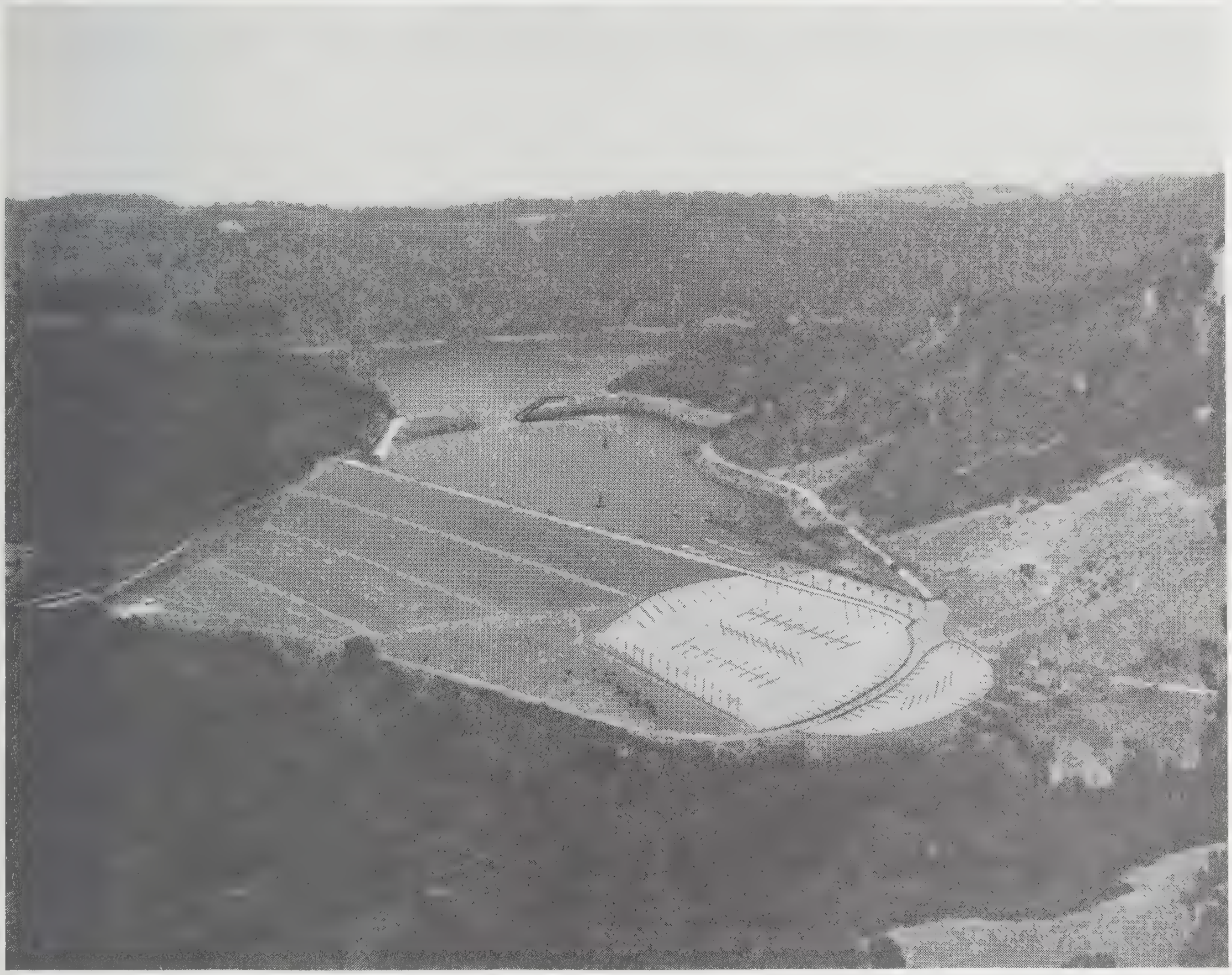
*Note 1 -- Water surface areas are not included.
Note 2 -- District's Board of Directors increased the acreage set aside for educational use areas to almost 6,000 in 1976.

Recreation sites were to be developed and made available in accord with timetables and priorities which were to be determined in recreation management plans prepared by the District's staff. The recreation plan for Upper San Leandro Reservoir described in this document ~~are~~ is consistent with these provisions of the LUMP. Upper San Leandro was specified as a site for future recreation development in the LUMP.

The District operates under the provisions of the Municipal Utility District Act of 1921, as amended. The Act gives broad power and full authority to provide a variety of services, including through contract or otherwise, to construct, maintain, improve and operate public recreational facilities appurtenant to any water reservoir owned or operated by the District.

# BUCKHORN RESERVOIR AREA TRAIL SYSTEM





# Appendix F
# Theoretical Water Conservation Measures

This appendix describes water conservation measures evaluated in the development of the Water Supply Management Program which were rejected from further consideration. The reasons for rejecting a measure is included in the discussion of each measure.

## Expansion of Leak Detection Program

Currently, the District has two leak detection crews which survey the distribution system with sonic leak detection equipment. Leak detection efforts located approximately 0.5 to 1.5 MGD of leaks each year. The leaks are then repaired or in some instances a section of pipe is replaced. The leak detection program maintains a low (7% to 8%) unaccounted-for water loss rate.

The District could purchase additional leak detection equipment and expand efforts to locate leaks within the distribution system. However, with current staffing levels, the leak detections crews are capable of locating more leaks than the pipeline maintenance crews are able to keep up with. Therefore, to expand this effort would require acquisition of not only leak detection equipment but also additional equipment, and staffing, for pipeline repairs.

Considering that the District's unaccounted-for water loss rate is low by industry standards, and that an increased leak detection effort would require substantial equipment and staffing increases, expansion of this program is not considered feasible or justifiable.

## Expansion of Water Saving Device Distribution

As previously discussed in Chapter III, EBMUD plans to distribute approximately 20,000 retrofit kits per year to single and multi-family residential customers. During drought periods, the number of kits distributed would increase in an effort to further assist customers in responding to water shortage conditions.

The District could increase the number of kits distributed during normal years. However, since the kits, particularly the toilet displacement bags, have a limited life there may be more effective methods of increasing water use efficiency. For example, State legislation requiring ultra low water using fixtures would provide permanent water savings, whereas the retrofit kits tend to provide only temporary savings.

Assuming an additional 10,000 kits were distributed each year, the potential water savings could be 2.8 MGD in 2020, an increase of 0.9 MGD over the current effort. This estimate may be high since it does not account for unknown factors such as longer showers or double flushing of toilets, which may result from the use of the retrofit devices.

As described in Chapter III, the District would support State legislation mandating the installation of ultra low water using fixtures. The distribution of retrofit kits would best serve as a means of responding to a drought or

other emergency situation. For these reasons, expansion of the water saving device distribution measure has not been proposed for the Water Supply Management Program.

### District Installed Water Saving Devices

An alternative method of distributing the water saving devices is for the District to offer to install the devices in customers homes. This effort would probably result in more water saving devices being installed and therefore greater water savings. However, the cost to the District to both provide the kits and then install them greatly increases the cost of the program.

In evaluating this measure, it was assumed that 30,000 kits would be distributed each year, and that 75 percent of the kits would be installed (50 percent by District personnel). Furthermore, it was assumed that 15 percent of the devices would be removed, by the customer, after a short period due to dissatisfaction. The estimated annual cost to the District for this program is estimated to be $638,000 per year, five and one-half times the proposed expanded device distribution.

The water saving devices have the potential for saving about 9.8 gpcd (or 23.00 gpd and 17.6 gpd for single and multi-family residential households, respectively in the year 2020). The total water savings in the year 2020 is projected to be up to 4.3 MGD. This is an increase of up to 2.4 MGD over the current measure and 1.5 MGD over the expanded device distribution.

Other water agencies have installed water saving devices in individual customers homes. However, these efforts have been associated with pilot programs in an attempt to quantify actual water savings of the devices in homes. The high cost of large scale installation of water saving devices in customers homes makes this alternative infeasible. The additional water savings is small in comparison to the increased cost. In addition, as described previously, the device distribution measure would best serve as a response to a drought emergency. Therefore, this measure was not considered appropriate for the District's water conservation program.

### System Capacity Charge Discount

To provide an incentive for installing low water using fixtures in new residential developments, the District could offer a discount on the System Capacity Charge (SCC) paid by all applicants for water service. The District would establish criteria whereby developers who install 1.5 gal/flush toilets, 2.0 gpm showerheads, low water using dishwashers and hot water pipe insulation could receive a discount on connection fees.

As a voluntary program it is impossible to determine the level of response to a SCC discount measure. The level of response would depend, partially, upon the amount of the discount. The discount would have to exceed costs associated with the installation of the required materials, as well as, any administrative costs involved in applying for the discount.

It is difficult to assess the response by developers to this type of incentive program. Assuming 10 percent of the new housing units incorporate the water saving fixtures, approximately 0.2 MGD could be saved by the year 2020. The incremental cost of a home built with these fixtures is estimated to be about $400. Assuming a $500 SCC discount would be sufficient to encourage developers to install the fixtures then the annual cost of the program would be about $160,000 per year.

This measure has not been proposed for the District's water conservation program because of the uncertainty in how new customers would respond to the incentive. In addition, as described in Chapter III, the District would support State legislation to mandating the installation of ultra low water using fixtures in all new construction. This is believed to be a more effective method of implementing the requirement, and would have the added benefit of saving water state-wide.

### Voluntary Toilet Replacement for Residential Customers

Since 1978, new construction has been required to install toilets which use no more than 3.5 gal/flush. Homes built before 1978 use about 5.5 gal/flush. Toilets are currently available which use no more than 1.5 gal/flush.
The District could encourage installation of 1.5 gal/flush toilets in existing single and multi-family homes by offering customers a $50 rebate to customers who purchase and install the toilets. The effect of a rebate on encouraging customers to install the ultra low flow toilets is unknown.

In evaluating this measure, it has been assumed that only those customers who were replacing broken toilets or remodeling a bathroom would consider installing the ultra low flow toilets. Since the cost of the 1.5 gal/flush toilets is comparable to other toilets the $50 rebate would act as an incentive to customers. Because customers would be replacing toilets anyway, and the program would be voluntary, no additional customer costs have been assumed.

The estimated potential water savings for this measure, assuming 5 percent of the District's customers replace toilets with ultra low flow toilets by 2020, would be 0.8 MGD. This calculation assumes that 80 percent of the toilets installed are in homes built prior to 1978.

To implement the program, customers would have to apply to the District for a rebate, and District personnel would be required to inspect customers' homes to assure installation of the toilets. The District's cost for administering the program and inspecting customers' residences is estimated to be $120,000 per year.

The uncertainties involved with this measure are significant. A toilet rebate program has never before been attempted on a large scale. To achieve a 5 percent response of residential customers by the year 2020 would mean over 900 customers per year would have to accept the rebate offer from the District. A $50 rebate may not be sufficient to influence enough customers for water savings to be significant. The District will test the responsiveness of customers to monetary incentives through the proposed landscape rebate pilot program. The results of the pilot program may indicate that rebate programs are effective in encouraging water conservation.

There is also uncertainty associated with the water savings from the ultra low flush toilets. Customers may not be satisfied with their performance and may decide to place old fixtures back into use. Also double flushing may reduce actual water savings. As previously discussed, the District would support State legislation mandating the installation of ultra low water using toilets, showerheads, and appliances in all new construction. Following adoption of such legislation, and after additional experience is gained on the public acceptance of ultra low flush toilets, the District could consider the replacement of toilets with the ultra low flush models. At that time an incentive type measure, as described here, may be beneficial and will be evaluated in the future.

### Mandatory Toilet Replacement For Residential Customers

In developing the Water Supply Management Program, the District also considered a mandatory measure to force the installation of ultra low flush (1.5 gal/flush) toilets in existing homes through State legislation. Under this measure residential customers would be required to install 1.5 gal/flush toilets in all homes at the time of resale.

It is estimated that customers cost for this measure would be $300 to $400 dollars for each toilet (including purchase and installation) replaced in the home. District wide this would amount to an estimated $9,600,000 to $12,800,000 per year in customers costs. Potential water savings from this measure in the year 2020 may be 12.8 MGD.

While the potential for water savings is significant, it is not know how customers would respond to such a drastic conservation measure when water supplies are more than sufficient most of the time. This measure has recently been imposed in two California communities, however, these communities are also facing severe water shortages. The long-term effect of these measures is not known.

This measure has been rejected from further consideration at this time because of its high cost both to customers and to the District. However, the District may examine this measure in the future if State legislation mandates the use of ultra low water using fixtures in all new construction.

### Mandatory Toilet Retrofit for Non-Residential Customers

This mandatory measure would require the installation of retrofit devices on toilets in all commercial, institutional, and industrial establishments at the time of resale of the building. The devices consist of inserts which reduce the flow through toilets generally found in commercial buildings.

It is estimated that the cost to non-residential customers would be negligible to retrofit each toilet. The District's cost to inspect buildings when new accounts are opened is estimated to be $15,000 per year. Potential water savings from this measure is projected to be 0.5 MGD in the year 2020.

On the surface this measure seems rather simple to implement. However, administration of the measure could

prove to be very difficult. A visual inspection of toilets may not indicate whether they have been retrofitted or not. Customers may not be willing to spend the time or the money on even a simple retrofit procedure. There would also be the question of who would be responsible for the retrofit, the buyer or the seller of the property.
Details on the implementation and administration of the program could be worked out, but it is doubtful that customers would respond positively to such requirements. Since the District's approach towards water conservation has been through voluntary measures, this measure has not been proposed for the District's water conservation program. Furthermore, the inserts used to retrofit toilets will be offered to non-residential customers through the water audit program.

### Landscape Rebate

The Water Supply Management Program proposes to determine the effectiveness of offering rebates to customers who install low water landscapes that meet District criteria. A pilot program is necessary since this approach towards encouraging conservation has not been attempted before. A full scale landscape rebate program may be, at some future point in time, an effective conservation measure. However such an approach needs to be tested.

The effectiveness of a landscape rebate program largely depends on the customers response to a monetary incentive. Water savings of 1.3 MGD could be achieved by 2020 if 10 percent of the existing single and multi-family customers reduce outside water use by 25 percent. The monetary incentive necessary to achieve this level of response is unknown.

The pilot program proposes a rebate of $300 per single family household, and $300 per 5,000 square feet of landscaped area for multi-family complexes, to test the response rate of customers to this type of incentive. Higher rebates may actually be needed to encourage a significant level of response. The cost of the rebate program would vary with the amount of the rebate and the level of customer response, and cannot be adequately determined at this time.

The District will continue to evaluate the potential benefits of the landscape rebate program as further data becomes available.

### Voluntary Dual Line Plumbing

A dual line plumbing system for residential households consists of independent water lines coming from the bath and shower which go to a filter system. Partially treated water from the filter would then be used for underground irrigation of shrubs and trees, thus reducing landscape irrigation water needs. Under a voluntary approach to this measure the District could encourage the installation of dual plumbing systems in new homes through a discount on connection charges. The discount would have to equal the cost of installing the system to be effective.

Dual line plumbing systems for individual homes are very costly, adding approximately $2,000 to the cost of a home. Furthermore, there are many other factors to consider in operating such a system. A filtration system would require continuous operation and maintenance to assure safe and continued use. There is no assurance that a homeowner would even be willing to use the system.

There are also health concerns with dual line plumbing that would have to be addressed. For example, use of partially treated water on landscaping may be a concern even if applied underground. Excessive application could result in ground saturation and ponding of water on the ground surface.

Even if the cost, public acceptance, and health issues were resolved this program would only save about 0.1 MGD, assuming 5 percent of the new homes built up to the year 2020 included the dual plumbing system. The cost of a voluntary program, with a $2,000 connection fee discount, would be about $235,000 per year.

The low water savings, high cost, public health, and customer acceptance of this measure make it unsuitable for the District's water conservation program.

### Mandatory Dual Line Plumbing

The District also considered a mandatory measure to require installation of dual line plumbing systems (as described above) in all new single family homes. This measure would have all the problems of the voluntary measure but the full cost of the dual line plumbing systems would be borne by customers. Since more systems would be installed District-wide, more water would theoretically be saved. However, there would be no

assurances that the systems would be used. In fact, installation of the systems would have to allow for non-use of the system by providing a connection to the sewer system.

This measure has also been rejected from further consideration for the same reasons as the voluntary measure, plus a mandatory measure is considered to be too restrictive on customers and inappropriate for the District's water supply situation.

### Water Efficient Technology

New commercial, institutional, and industrial customers could be required to employ the latest water saving technology. This would include efficient cooling systems, recycling of process water, and low water using sanitary fixtures. The measure would focus on inside water use.

To implement this measure, the District would establish criteria on water using equipment, processes, and fixtures. The District would then either encourage the cities and counties within the service area to adopt the criteria for use by building officials in granting building permits, or the District may impose the criteria on new customers as a condition of water service.

Assuming that 50 percent of the new customers would be affected by the water efficiency requirements, and that water savings of 10 percent is achieved, then 0.7 MGD may be saved by the year 2020. Assuming the District administers this measure, the District's cost is estimated to be approximately $100,000 per year.

If available water saving technology is also effective in reducing total operational costs then requiring such technology would benefit the customer, and would probably occur without any regulation by the District. However, if regulations would force a business of industry to employ technologies that were not cost effective then the result would be to discourage business from coming to the East Bay area. This ultimately could have an impact on employment and the economy of the East Bay area. The cost to customers for requiring water efficient technologies is uncertain. Also, it would be a difficult task for the District to stay on top of all water saving industrial processes to be able to regulate which processes are water efficient, as well as, cost efficient.

Industrial customers have reduced water use in the past 10 years through process changes. These changes were a response to severe drought conditions in 1976-77 and also economic necessity to remain competitive. It would be inappropriate for the District to mandate water use practices by customers when the restrictions would be counter productive for the customer. If water saving processes are beneficial to the customer they will occur without regulation. Therefore, this measure was not proposed for the District's water conservation program. The District will, however, work with customers, through the water audit program, to assist in identifying water saving practices which could be employed by customers. This would be a much more effective means of encouraging water savings.

### Ultra Low Flow Toilets and Showers in New Construction

One of the additional measures the District proposes (see Chapter III) is to support State legislation mandating the installation of ultra low flow toilets and showerheads in all new construction. Another method of implementing this measure would be for the District to require these fixtures within the service area even without statewide support.

The District could either work with individual cities and counties within the service area to adopt appropriate ordinances or the District could impose the ultra low flow fixtures as a requirement of new service connections. The potential water savings for this measure (implemented by the District) is the same as if it were implemented statewide, 2.1 MGD by the year 2020.

District implementation of this measure is not seen as effective as statewide implementation since economies of scale could not be realized. However, should State legislation fail to gain the necessary support then the District may wish to consider this alternative.

# Appendix G
# Project Costs for Additional Terminal Storage

**(Million Dollars - 1988)**

| ITEM | PINOLE RESERVOIR | |
|---|---|---|
| | Spillway 313 ft. (29 KAF) | Spillway 340 ft. (50 KAF) |
| 1) Construction Cost | 49.2 | 54.4 |
| 2) Design Engineering and Construction Support | 2.8 | 3.0 |
| 3) Contract Administration | 1.5 | 1.6 |
| 4) Material Engineering | 1.0 | 1.1 |
| 5) Property | 0.0 | 0.0 |
| 6) Reservoir Filling | 2.4 | 3.8 |
| TOTAL | 56.9 | 63.9 |

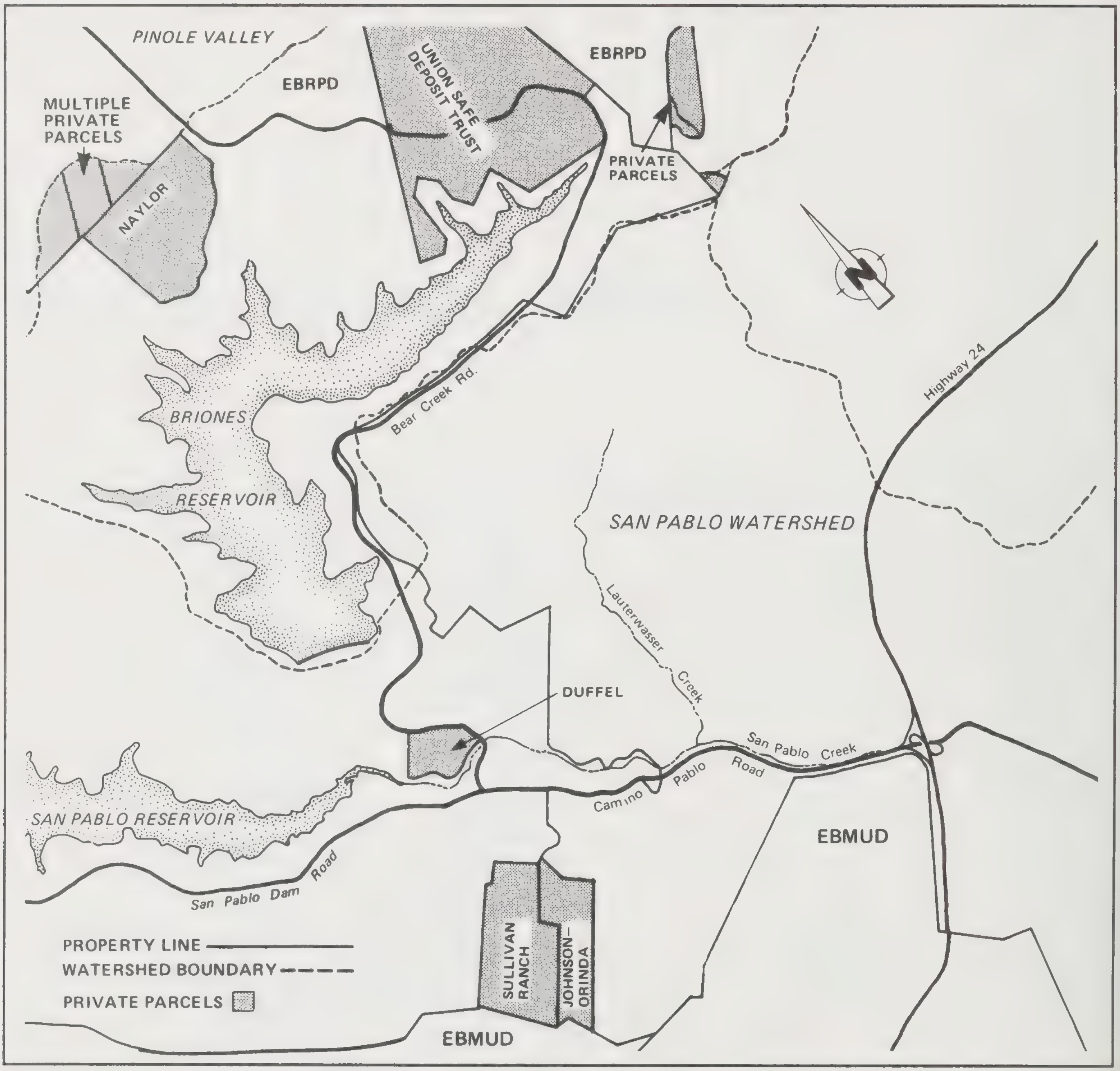
| ITEM | BUCKHORN RESERVOIR | |
|---|---|---|
| | Spillway 680 ft. (80 KAF) | Spillway 745 ft. (145 KAF) |
| 1) Construction Cost | 94.9 | 134.1 |
| 2) Design Engineering and Construction Support | 5.3 | 7.5 |
| 3) Contract Administration | 2.9 | 4.0 |
| 4) Material Engineering | 1.9 | 2.7 |
| 5) Property | 3.5 | 3.5 |
| 6) Reservoir Filling | 8.5 | 17.4 |
| TOTAL | 117.0 | 169.2 |

| ITEM | LOS VAQUEROS RESERVOIR (EBMUD SHARE ONLY) Spillway 560 ft. (155 KAF) |
|---|---|
| 1) Construction Cost | 139.0 |
| 2) Design Engineering and Construction Support | 13.9 |
| 3) Contract Administration | 8.3 |
| 4) Material Engineering | 5.6 |
| 5) Property | 19.0 |
| 6) Reservoir Filling | 13.0 |
| TOTAL | 198.0 |

# Appendix H
# Possible Watershed Acquisition

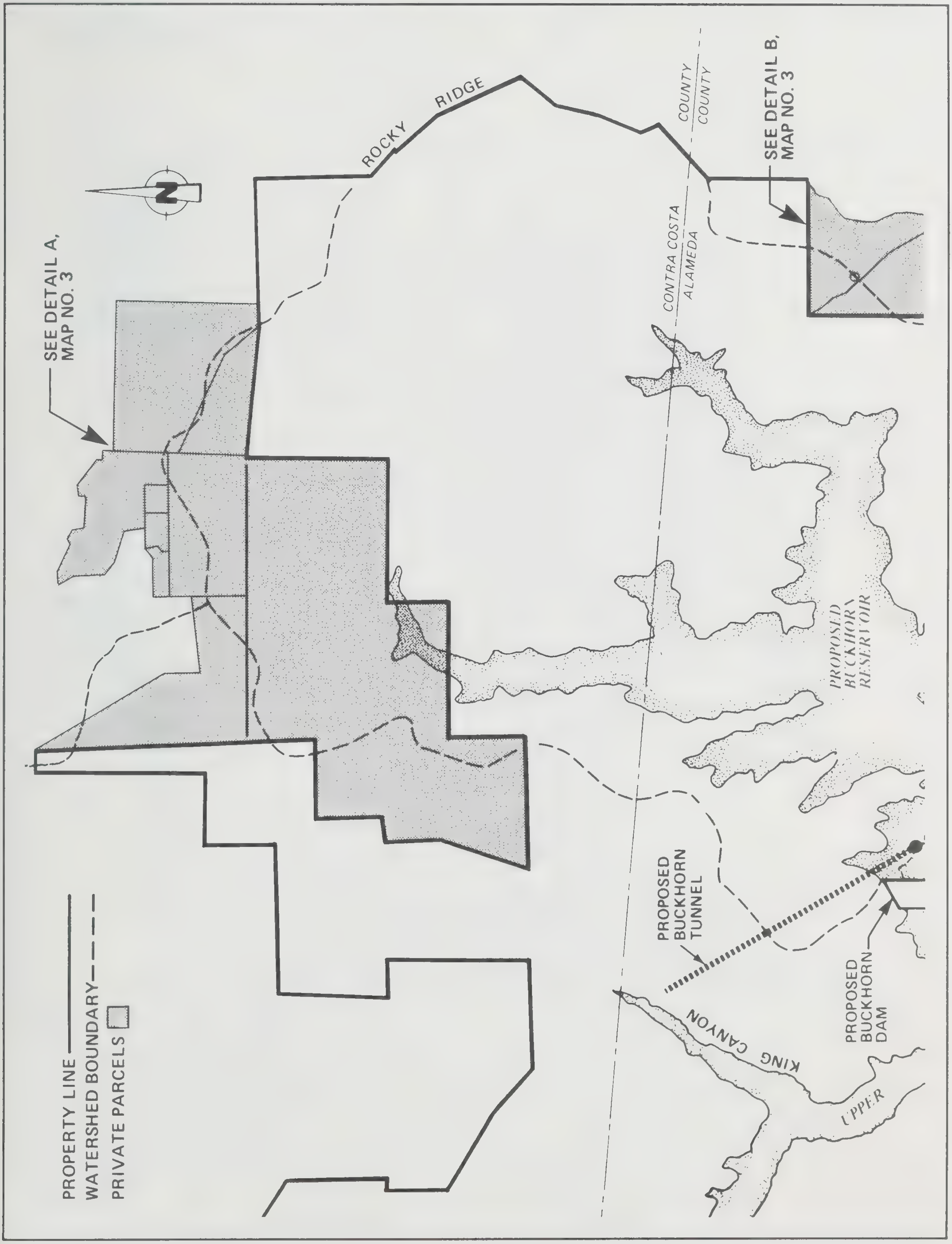
| WATERSHED | PARCEL IDENTIFICATION | WATERSHED | PARCEL IDENTIFICATION |
|---|---|---|---|
| Briones | Multiple private parcels | Pinole | Pereira, F. |
| Briones | Naylor | Pinole | Pereira, F. |
| Briones | Union Safe Deposit | Pinole | Pereira, F. & J. |
| Buckhorn | A.J. Carr | Pinole | Pereira, M. |
| Buckhorn | Alongi | Pinole | Pereira, M. |
| Buckhorn | Lawrence | Pinole | Pereira, M. |
| Buckhorn | Morgenthaler | Pinole | Pereira, M. |
| Buckhorn | Peres | Pinole | Pereira, M. |
| Buckhorn | Rhoda | Pinole | Santos |
| Buckhorn | Vanier | Pinole | Saraiva |
| Pinole | Burg | Pinole | Sears |
| Pinole | Cunha, A. | Pinole | Soehngen |
| Pinole | Cunha, M. | Pinole | Watson-Dutra |
| Pinole | Nunes | Pinole | Westgard |
| Pinole | Pereira, A. & M. | Pinole | York |
| Pinole | Pereira, E. | San Pablo | Duffel |
| Pinole | Pereira, E. | San Pablo | Johnson-Orinda Ranch |
| Pinole | Pereira, E. & J. | San Pablo | Sullivan Ranch |
| Pinole | Pereira, F. | Upper San Leandro | Bruzzone |

## Briones and San Pablo Watersheds (in part) Map 1



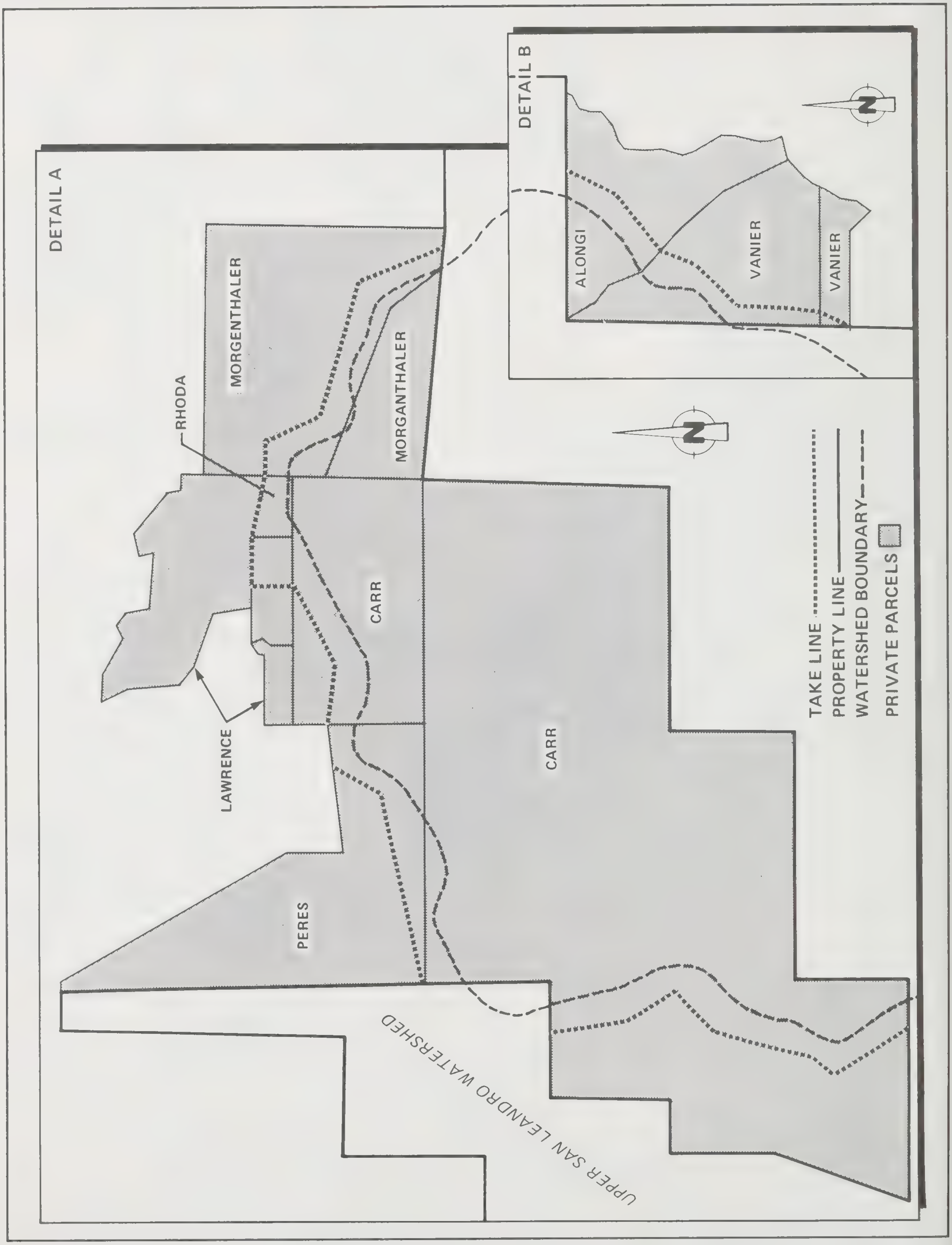
## Buckhorn Watershed (in part)

Map 2



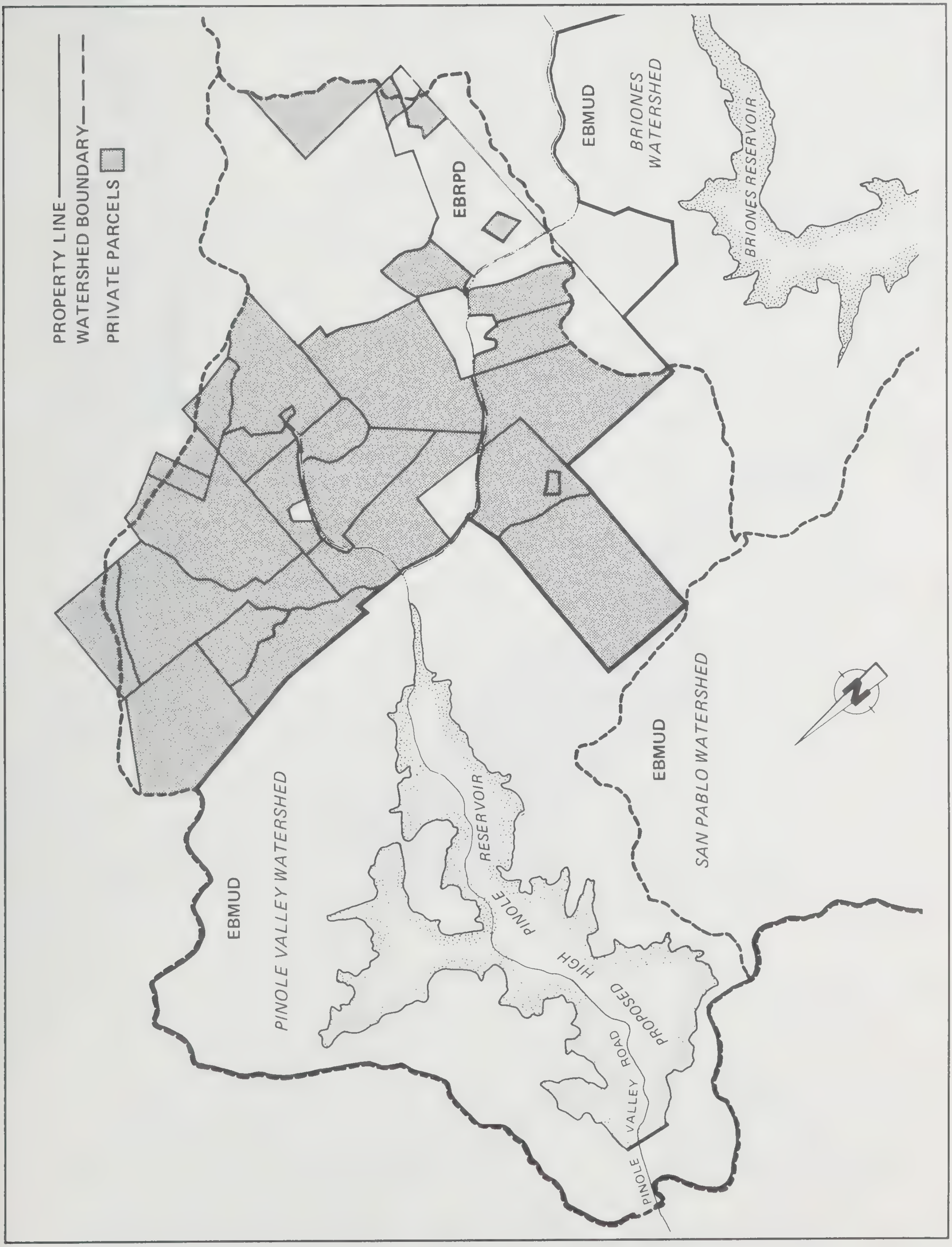
# Buckhorn Watershed (detail)

Map 3



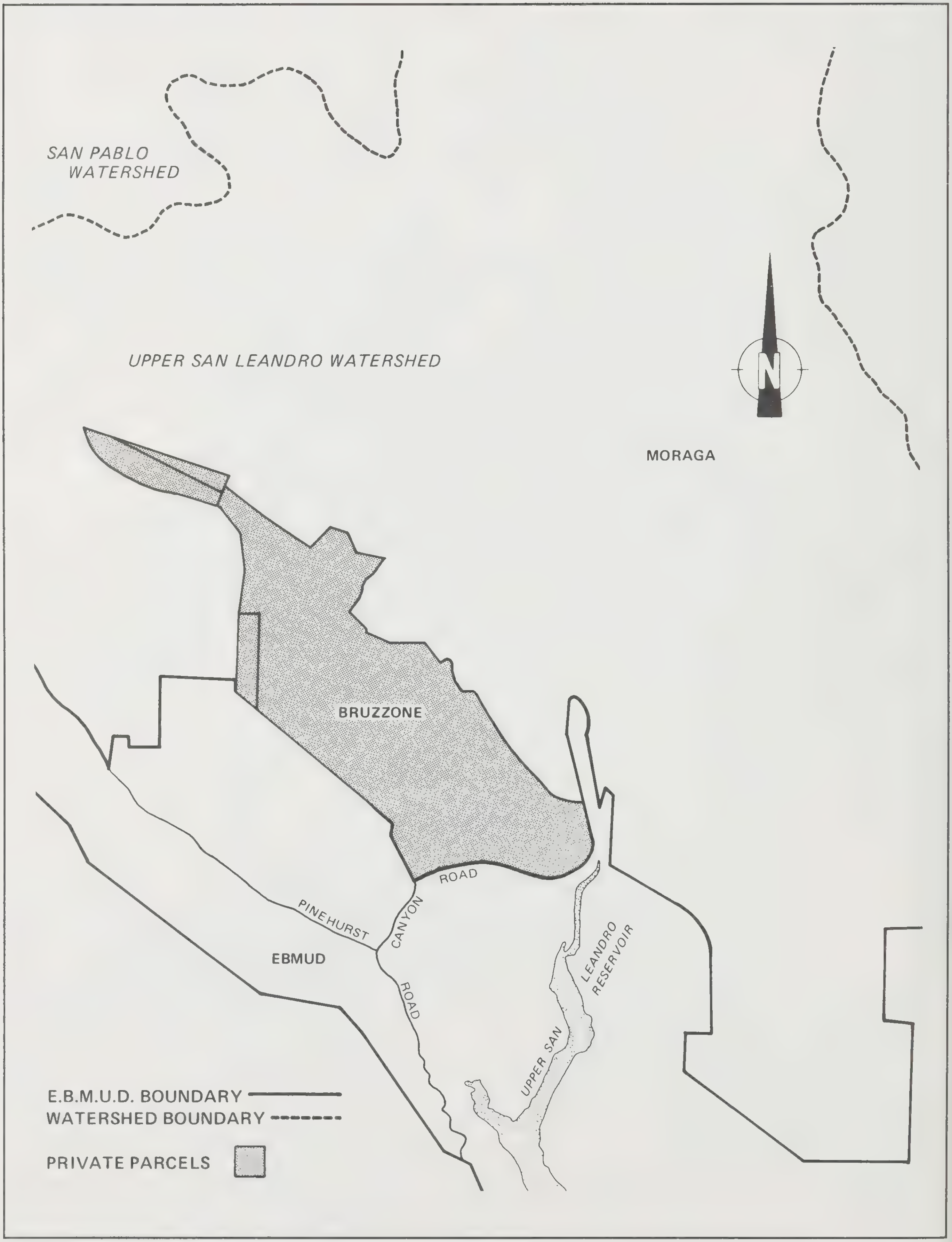
# Pinole Watershed

Map 4



## Upper San Leandro Watershed (in part)

Map 5



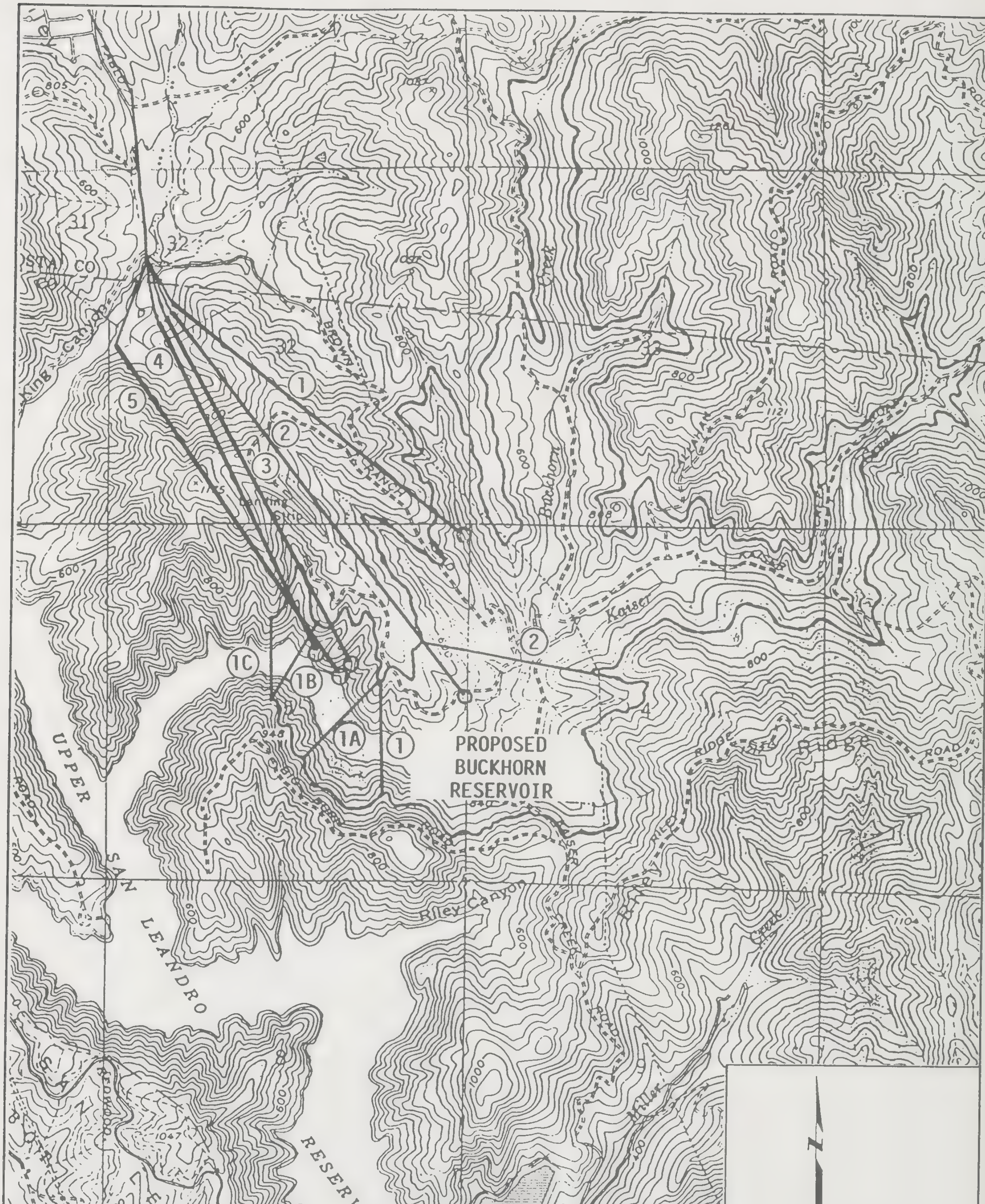
# Appendix I
# Consultant Costs

The Cost incurred by those consultants making direct contributions to this report are listed below.

- William B. Maddaus, Brown and Caldwell, Consulting Engineers
  (Purchase Order No. 510-22957-A, cost not to exceed $10,000)
- Joseph B. Franzini, Professor of Civil Engineering, Stanford University
  (Purchase Order No. 510-23042-A, cost not to exceed $5,000)
- Bernard B. Gordon, Consulting Engineer
  (Purchase Order No. 514-7209AZZ, cost not to exceed $12,500)
- John Boland, Consultant
  (Purchase Order No. 210-20759-A, cost not to exceed $7,500)
- Melissa Blanton, Editor
  (Purchase Order No. 510-23044, cost not to exceed $5,000)
- Thomas Mongan, Editor
  (Purchase Order No. 514-23031, cost not to exceed $13,000)
- Miller-Starr-Regalia, Attorneys at Law
  (Purchase Order No. 510-37301-A, cost not to exceed $19,500)

Costs incurred by other consultants have been cited in other reports previously prepared.

# Appendix J
# Buckhorn Tunnel Alternatives




| | | |
|---|---|---|
| GEOMATRIX | LOCATION OF PROPOSED RESERVOIR, DAM AXES, AND TUNNEL ALIGNMENTS<br>Reconnaissance Geologic Study - Buckhorn Dam Site<br>Alameda County, California | Figure<br>1<br>Project No.<br>1239A |